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QUALITY CONTROL

HEARING

BEFORE THE

TASK FORCE ON SELECTED DEFENSE PROCUREMENT MATTERS

OF THE

COMMITTEE ON ARMED SERVICES UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

SECOND SESSION

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QUALITY CONTROL

THURSDAY, OCTOBER 18, 1984

U.S. SENATE,
COMMITTEE ON ARMED SERVICES,
AD HOC TASK FORCE ON SELECTED
DEFENSE PROCUREMENT MATTERS,
Washington, DC.

The task force convened, pursuant to notice, at 10:05 a.m., in room SR-253, Russell Senate Office Building, Senator Dan Quayle (chairman of the task force) presiding.

Present: Senators Quayle and Levin.

Staff present: Alan R. Yuspeh, general counsel; David S. Lyles and John J. Hamre, professional staff members; Marie Chaillet, Kathleen L. McGuire, Lisa M. Tietge, and Shelly Turner, staff assistants.

Also present: Bernard L. Toon, assistant to Senator Quayle; Charles C. Smith, assistant to Senator Dixon; Ralph White and Linda Gustitis, assistants to Senator Levin.

OPENING STATEMENT BY SENATOR DAN QUAYLE, CHAIRMAN

Senator QUAYLE. The committee convenes today to receive testimony on the issue of quality assurance problems in the production of missiles at the Tucson plant of Hughes Aircraft Co.

I would like to take a moment this morning to place into context the hearing which the task force is having. In June of this year, the U.S. Navy disassembled three Phoenix missiles which had been manufactured in the Tucson facility of Hughes Aircraft. Upon disassembly, the Navy identified certain characteristics in the construction of those missiles which it regarded as reflecting imperfect workmanship at the Hughes Aircraft.

Some of the defects identified were actually design questions, such as whether certain wires or connections ran too close to sharp edges inside the missile. Other problems that were identified related directly to questionable workmanship, such as technique in soldering on circuit boards.

As a result of quality assurance issues that were raised through the Navy inspection, events have developed to the point that none of the military departments are accepting delivery of missiles from the Hughes Aircraft Tucson facility, final assembly of missiles at the facility has been suspended, and progress payments to the contractor are in a state of suspension.

At the same time, I should mention that the contractor has been energetically working for several months to develop a corrective action plan which will address the concerns that have been ex-

pressed by the three military departments regarding quality assurance at Tucson. It is my understanding that the development and implementation of this plan have been an ongoing cooperative effort between the Department of Defense and Hughes, and I am certain that we will receive further information about the status of the plan today.

This episode raises a number of questions which are of substantial concern to this task force and the Armed Services Committee in the Senate.

First, what permitted the apparent breakdown in quality controls at the Hughes Tucson facility? What were the shortcomings of the contractor's quality control system, and why didn't the Air Force plant representative office fully identify and remedy the problem before it reached the state of seriousness that it apparently did?

Second, how serious are the defects that have been identified in the missiles that were inspected?

Third, do the workmanship practices at the Hughes facility bring into question the reliability of Phoenix, Maverick, or TOW missiles that have already been accepted by the Department of Defense?

I would note for the record that it is my understanding that each of these missiles has passed various acceptance tests prior to acceptance by the respective services, and that such tests did not reveal workmanship shortcomings.

Fourth, what is the status of the corrective action plan that Hughes has proposed and, when fully implemented, should the plan be adequate to ensure that the workmanship problems will not recur?

Fifth, in the broadest sense, what are the lessons that we should learn from this experience with respect to quality assurance in the procurement of weapons systems?

To avoid any misunderstanding, let me note that there are extensive requirements and regulations dealing with mandatory quality control mechanisms at defense contractor facilities. This is a case where those requirements have apparently not been observed or enforced.

Hopefully this is a single, isolated instance, but every defense contractor must understand that the highest standards of workmanship in the manufacture of weapon systems will be required and a failure to meet those standards will reflect adversely on the ability of companies to continue to sell to the Government and will result in the Government's demanding appropriate remedies.

I should also like to note for the record of this hearing that staff of the committee serving both the majority and the minority have inspected the Hughes Tucson facility within the last week and have met with representatives of the Air Force plant representative office at the facility as well as representatives of the company. These inspection visits have been in preparation for this hearing.

I might say also that there are basically two approaches that we will be taking. One is the somewhat short-term approach—what do we do now. We have to look at the missiles that are in the inventory, that have been delivered, and what kind of remedies will be proposed. My own personal opinion is that the ultimate remedy is nothing short of making sure that the highest quality is main-

tained, and that deficient missiles are going to have to be returned to the company and fixed or replaced in an appropriate manner. The long-term approach to this situation is what are we going to do about a system that apparently did not work.

I think that these are the two approaches that I will pursue. This is the first time that this committee has examined the issue of quality assurance. Quality assurance, and the quality of weapons, be they missiles or anything else, is of the utmost and perhaps the highest priority that we must have. We must have weapons of the highest quality, second to none. I hope that that goes really without saying, and it is unfortuante that it would even be in question.

I now turn to my colleague, Senator Levin, for his opening statement.

Senator LEVIN. Thank you, Mr. Chairman.

On August 27, 1984, the Air Force, acting for itself and the Army and the Navy, took a relatively drastic step in the procurement world. On that date, the Air Force officials halted the progress payments to one of our largest contractors, the Hughes Aircraft Co. The amount of the money withheld was $37.9 million. By the end of the month, if payments are not resumed, the Air Force will have withheld three such payments totaling over $100 million.

Those payments have been withheld because it is the unanimous opinion of the Navy, the Army and the Air Force that the products supplied by Hughes Aircraft at Tuscon are either not in compliance with contract specifications or demonstrate sufficient quality problems to raise serious concern about the future reliability and effectiveness of the Phoenix, Maverick, and TOW missile systems, all made by Hughes.

One question at hand is why the quality assurance program didn't result in action. Why didn't the quality assurance program catch the defects, or the inadequacies, or the variances, or whatever term it is that we wish to apply to these deficiencies? Let's look at the chronology of the actions that led to the stopping of payments.

On June 6, 1984, the Navy decided to tear down the Phoenix missile in preparation for briefing the Secretary of the Navy on a milestone decision to go from limited to full-scale production of the Phoenix C. At that time, the Army found alarming defects and on June 22, the Navy formally halted further acceptance of Phoenix missiles.

From June 26 to 28, the Navy disassembled two other missiles and found more of the same problems.

On July 17, the Army disassembled four TOW missiles finding similar problems as the Navy.

The Air Force followed suit with a tear-down of the Maverick missile on July 23. Those tear-downs produced 68 flaws and variances, and perhaps 33 to 40 percent of those flaws and variances were contract violations. The rest were violations of sound engineering practice at a minimum.

Given the serious findings of poor quality in every one of these inspections, the Air Force and the Army followed the Navy's lead and stopped acceptance of their missiles on August 8 and August 14 respectively.

On August 27, the Air Force, acting for all three services, completely blocked any further progress payments. I am sorry to say that it appears that the decisions involved in disassembling these systems for inspection, and subsequently stopping the progress payments were not as a result of the military's quality assurance process, but rather were as a result of fortuitous circumstance. Some people took out-of-the-ordinary action. It wasn't the quality assurance process, we believe, that resulted in finally stopping payment and stopping acceptance of these missiles.

It was totally unrelated action by some individuals who decided at a certain step of the procurement process to test and tear down one of these missiles. I commend those individuals for their actions but we must ask ourselves what are the effects and results for our national defense when we put into place a system that lulls the services, the Department of Defense, and even the Congress, into a drowsy acceptance that all is well with the quality of our weapon systems.

What is the condition of numerous systems bought under the guise of the military's quality process? The Department of Defense monitors quality through a process spelled out in a document known as MIL-Q-9858A. This document, and its accompanying handbook, requires the military services to review the contractor's quality assurance plan to determine whether that plan will result in delivery of quality products.

This review includes a determination of whether the contractor has plans to ensure that production-line work instructions are adequate to deliver uniform and reliable products; whether drawings are up to date; whether measuring and testing equipment is properly calibrated and maintained; whether raw materials used are suitable; and handling storage and delivery protects the quality of the item.

The document, MIL-Q-9858A, also requires the contractor to implement an inspection system to identify nonconforming material produced by the contractor. In the case of Hughes Aircraft, at Tucson, the contract administrator for all three services is the Air Force.

With an onsite Air Force procurement office [Afpro], staffed by about 103 people, the Air Force has the job of monitoring Hughes performance. Of those 103 people, 35 are authorized to perform quality assurance. The quality office with the Afpro monitors the contractor's performance through a series of forms used to track contractor compliance with the Air Force quality requirements.

The most serious type of noncompliance, indicating a systemic or recurring problem with possible adverse effect on weapon system production, is documented on a form 47. Since October 1982, the Air Force has issued 16 such forms 47 regarding the operation of Hughes on these missiles. These forms are issued to the chief operating officer of the corporation. They require corrective action by the corporation within a specified time.

In just one of these instances, the head of the Afpro issued a form 47 in October 1982. The Air Force has received a series of contractor-submitted plans for correction and has found each plan inadequate, but no action was taken following those findings of inadequate plans. This battle of forms was still in progress when the

Air Force stopped payment on the contract in August 1984, more than 2½ years later for reasons unrelated, again, to the quality assurance program, at least to the best of our information.

And again, I emphasize that, because I think it is important, it is our conclusion that the decision to stop payments and force remedies on the ongoing situation does not appear to be related to the quality assurance program. The decision to disassemble the missile came from outside the process, for other reasons.

Now while this tug of war between the quality office and the contractor continues, the judgment is pending on the missile systems that have already been paid for and delivered to the field.

One form 47, dated July 17, 1984, sent by the Afpro head, Col. Gary Hagan, who is a backup witness this morning, and cosigned by Mr. Alfred Coult, Chief, Air Force Quality Assurance Division, reads as follows: "Receiving inspection skip lot sampling procedure is not in compliance with contractual documents," and then enumerates the document numbers.

"As a result of the above inspection method, approximately 10,000 TOW missiles containing nonconforming hardware have been delivered to the government." I am going to repeat that last line. "As a result of the above inspection method, approximately 10,000 TOW missiles containing nonconforming hardware have been delivered to the government."

What does this mean for those systems in the field? Can we be certain those missiles will work? And what is the impact on readiness if they don't? Ten thousand nonconforming missiles represents an incredible indictment of this system and raises questions about the reliability of those missiles to defend our country.

Second, and in a more general vein: We must address the state of quality in the defense industry. Mr. Willis Willoughby, Deputy Chief of the Naval Materiel Command for Quality Assurance, who was asked to be here this morning, I understand, but had to attend to some other Navy business on the west coast, was quoted in the September 17, 1984, edition of Defense Week as saying the following:

> This workmanship is getting to be of staggering proportion. Defects are certainly on the rise. Hughes doesn't look any different than other places. We see things that are just as badly done all over the country, from contaminated parts to unsoldered wires to terminals with no wires on them. I can just go right down the line.

I believe that it is incumbent upon the Armed Services Committee to investigate thoroughly the military quality assurance process, and that is why I urge this panel to look into the quality assurance process, and why I am so delighted that our chairman has decided to do so. To my knowledge, it is the first time that the Armed Services Committee has gotten into the quality assurance process, at least in the few years that I have been in the Senate.

Is the current system meaningful? If not, why not? Does the system tell us what we need to know? Does the system guarantee that we get the quality products we pay for, and particularly today, why didn't the quality assurance system trigger action on these three missiles? Why are we now in the position of having to redo what should have been done right the first time around?

One final point: We have a number of serious concerns with the Phoenix, TOW, and Maverick missile systems and specifically, as I

have indicated, we have evidence that as many as 10,000 TOW missiles containing nonconforming hardware are in the field.

At our earlier hearing, each of the military witnesses pledged that any nonconforming missiles would be returned to Hughes and repaired at Hughes' expense. That testimony has been called into question since then, so I would like to confirm today the status of those repair costs.

So, Mr. Chairman, we must move forward with great urgency with our inquiry into the health of the entire quality assurance process. Given the money that has been spent on these systems and the lives that depend every day on their successful operation, the Senate Armed Services Committee should turn its urgent attention to this process, and again I am thankful and grateful that the chairman has proceeded with this hearing today.

Senator QUAYLE. Thank you, Senator Levin.

Our first witness today is Gen. Bernard L. Weiss, Director of Contracting and Manufacturing Policy, U.S. Air Force. General Weiss is joined by Col. Gary Hagan, the commander of the Air Force Plant Representative Office at Hughes' Tucson facility, and Col. Robert Jennings, project manager for the Maverick missile.

The second witness is Maj. Gen. Jerry M. Bunyard. General Bunyard is commanding general of the Missile Command. General Bunyard is joined today by Col. James Lincoln, project manager for the TOW missile.

Our third witness today is Commodore William J. Finneran. Commodore Finneran is the assistant commander for systems and engineering with the Naval Air Systems Command. Commodore Finneran is joined by Capt. W. C. Bowes, project manager of the Phoenix missile.

Our fourth witness today is C. Blaine Shull, vice president for manufacturing and manager of Tuscon Activities, Huges Aircraft Co.

We will proceed in that order, with General Weiss going first.

STATEMENT OF BRIG. GEN. BERNARD L. WEISS, USAF, DIRECTOR OF CONTRACTING AND MANUFACTURING POLICY, HEADQUARTERS AIR FORCE; ACCOMPANIED BY COL. GARY HAGAN, COMMANDER, AIR FORCE PLANT REPRESENTATIVE OFFICE, AND COL. ROBERT JENNINGS, PROJECT MANAGER FOR THE MAVERICK MISSILE

General WEISS. Thank you.

I am Gen. Bernard Weiss, the director of contracting and manufacturing policy here on the Air Staff in Washington, DC. I have appeared before this committee before, and I have had about 28 years of acquisition, contracting, manufacturing, and quality-related experience in my background.

I will focus this morning on the main components of our quality program, and, I think, the challenges we face in obtaining compliance. I think an understanding of these components will start to answer a lot of the questions that were raised by both of you gentlemen. Further, I will describe the problems that we have experienced and, in particular, discuss some of the lessons learned with Hughes Aircraft Co.

At the outset, I must clearly state that Government actions with regard to Hughes have been a result of the consolidated and joint efforts of all of the services. The Air Force acts as an executive agent, but in fact our actions have been the integrated effects of the Army, the Navy, as well as the Air Force.

Ultimate responsibility for product quality and the assurance that a given company's product conforms to contractual specifications and the statements of work rests with the prime contractor. This is where that responsibility rests. The Government's role is to assure that the contractor's quality system is working and is reliable through periodic system checks, audits, and selected physical inspections of products on a preplanned and random basis.

The cornerstone of the quality program is the military specification, MIL-Q-9858A, entitled Quality Program Requirements. This document establishes the parameters of a quality system that a contractor must implement to ensure quality products are produced and delivered to the Government in accordance with the terms of the contract.

The military specification is the one most commonly invoked on Air Force and other DOD major weapon system contracts. It requires written procedures which will assure quality through prevention of defects, as well as through inspection of products and material in process.

I would like to underscore the point about prevention of defects. These written procedures must describe work operations in sufficient detail to track contractor performance in areas of design, development, receipt of material, production, assembly, testing, packing, shipment, and installation.

The specification requires supplies and services provided under the contract to be controlled during all phases to ensure conformance to contractual terms. It applies to products and services performed at the contractor's plant, as well as any other source, including subcontractor facilities.

I have summarized very briefly 9858A. Now let me outline the five steps that the Air Force uses in overseeing and enforcing contractor quality activities.

First, we review the contractor's written procedures to judge their adequacy. Before they are accepted, the procedures must clearly describe the quality measures and other requirements, and who is responsible for implementing them. Collectively, these company procedures encompass management functions at various organizational levels, such as at the corporation level, the senior management, middle management, and line management levels.

In large companies, system level procedures can number in the thousands. Manufacturing and inspection level procedures can number in the tens of thousands. Also manufacturing and inspection level procedures, which describe the work operations and the practices of assembly of hardware can change relatively often, and require continual update and attention. After the initial Government review, there is a continuing sampling process to review all procedures and the firm's compliance with the most current procedures.

The second of these five elements of the Air Force quality program is selected physical inspection, audits, and product tests to

verify the adequacy of the contractor's quality assurance program. Inspection and testing are generally done on a sampling basis. Selected contractor inspection stations are visited at random, or in some cases on a mandatory basis by Air Force quality assurance personnel. Air Force inspection and tests serve to verify and revalidate the results of inspections and tests performed by contractor. Air Force actions measure the effectiveness of contractor procedures and the accuracy of recorded contractor measurements.

To understand the magnitude of this task, I would like you to consider some statistics on the Hughes Aircraft plant in Tucson. At this facility there are more than 10,000 engineering drawings in use, requiring 18,000 work instruction packages. These are governed by 5,800 process specifications.

Over 27,000 separate manufacturing tests must be performed to produce hardware. There are 10,000 contractor inspection points and nearly 780 contractor employees performing quality assurance functions. Of this 780, approximately 700 inspectors and testers work on the factory floor during a given day.

Where there is a known or potential problem, the Air Force performs 100 percent inspection of the product until the problem is corrected through changes to the contractor's quality system. This means the contractor cannot proceed with material beyond a designated point in the manufacturing process without first passing Air Force inspection. This procedure is also used in many situations to monitor very critical characteristics. This level of inspection is necessarily kept to a minimum because it is very manpower intensive. At Hughes Tucson there are 35 Air Force quality assurance people, currently augmented by 17 additional personnel.

The fourth step is when we find deficiencies in the procedures or product inspections performed by the contractor. They are documented by the Air Force, and they are reported in writing to the contractor for corrective action. The contractor is then closely monitored by the Air Force to make sure that the corrective action is effective and the deficiency is eliminated.

The fifth and final component of the Air Force quality assurance program is final acceptance of the products for the Government. This is based in part on the records that the contractor and the Government have accumulated during the manufacturing process that indicate that the item has been inspected and tested as specified and meets the requirements of the contract.

AFPRO's, Air Force Plant Representative Offices, are responsible for contract administration at facilities such as Hughes Tucson. They include within their organization skills and centers of expertise for engineering, manufacturing, quality assurance, and contracting. We perform, where we are designated as the lead contract administration service function, services for the Army, the Navy, and NASA as well.

Each AFPRO is commanded usually by a full colonel. The AFPRO reports to the Air Force Contract Management Division at Albuquerque, NM, who in turn reports to the Commander of Headquarters Air Force Systems Command here at Andrews Air Force Base, MD.

I would like to kind of provide the setting, the environment that encompasses the functions of product quality assurance. At these

24 facilities that we are cognizant of, we have 260,000 contractor people working on Government programs. Ten percent of these contractor people are generally involved in quality assurance work.

Our AFPRO's range in size from 50 people to 300 people. About a third of our AFPRO work force is assigned to quality assurance functions. The average ratio between the contractor quality assurance personnel and the Air Force quality assurance personnel is 20 to 1. The average ratio of the total contractor personnel to quality assurance personnel at a given AFPRO is over 200 to 1.

Consider that at any given time, we have 10,000 active contracts with a face value of $138 billion. We are managing 130 major programs, and we do this with approximately 1,300 quality assurance men and women. I think you can see that the task is tremendously enormous, and involves responsibility that is equally enormous and difficult.

I would like to move now, or shift gears to talk about some of the quality problems that we find occur at places such as Hughes Aircraft at Tucson.

I have done a lot of work in the area of quality and there is a very famous American, unfortunately he is more famous in Japan, his name is Dr. Deming. He and Dr. Juran, after World War II, went to Japan and provided the quality system that they are world renowned for today in Japan.

What he says, basically, is that if you look at a large number of quality deficiencies, you will find that 85 percent of them are traceable to one thing, and that is management. As I go through this recitation, you will find that management tends to be the culprit for the lack of quality in a contractor's facility.

One, quality is not the number one company objective, unfortunately, in many of our plants. Lack of contractor management involvement and commitment to effectively correct quality and manufacturing problems early on is a second. The third is the attitudes that are shared by workers and management that are not conducive to building in quality. Fourth, giving priority to production schedules over quality. Five, insufficient emphasis is placed on defect avoidance. Sixth, the lack of clear workmanship standards. Seven, large numbers of engineering changes during the manufacturing process. Eight, inadequate internal contractor audits. Nine, the lack of timely and effective training and retraining of new and existing employees. Ten, the rapid increase in workload. Eleven, inadequate work instructions and manufacturing planning documents.

These are the deficiencies that we have found at Hughes, that we are attempting to correct with the support of the other services, the Army and the Navy.

We started seeing problems in quality way back in October 1982, when we did issue our first form 47 deficiency report. If you will look at our records to date, we have issued in the last 12 months through August, an average of 80 notifications of quality deficiencies each month at Hughes Tucson, 40 of which required written reply.

Back in October 1982, we conducted a manufacturing management and production capability review and found a high scrap rate, quality problems, and very low productivity. The Secretary of the

Air Force, Mr. Orr, met with the chairman of Hughes Aircraft Co., Mr. Puckett, in September 1983, to discuss these problems with the contractor. A get well plan was created; unfortunately there were slippages and progress was not made as we had originally planned.

We have a history of dialog with the contractor to fix problems, but unfortunately, we didn't see the corrective actions taking place, so in concert with the other services, and with due notice to the contractor, we suspended payments on the 27th of August.

If I had a look at a bigger picture of the issue of quality, not only at Hughes or within the services, but within our country, I find that there are some major lessons learned. I would like to submit for the record a study that was done by the Air Force back in November of 1979 which highlights some of the specific things that we have to do as a Nation, and we have to do as a Department of Defense, and American industry has to do as well.

One of these is to raise the level of importance of quality assurance within both Government and industry. I have never yet seen a president of an American aerospace company, or any industry in the United States, that came from a quality assurance background. Yet, when I go to Japan, I find presidents of their companies who have spent much time in quality assurance.

Two, improve upon the training of quality assurance people to keep pace with this advancing technology.

Three, attract and retain highly educated and technically oriented individuals to fill quality positions. You cannot attract GS–7, GS–9 and GS–11 personnel that have the requisite experience to do the right kind of job in our business. Increase the grade level. Increase the total number of civilian quality assurance people—1,300 people to do the job I described is almost overwhelming.

Maintain an effective and fully funded manufacturing technology program to provide both new manufacturing and quality assurance techniques within the Government and industry to stay current with advancing technology. Engage broader productivity and quality improvement efforts as the Air Force, the Army, and the Navy are trying to do in our Industrial Modernization Incentives Program.

Gentlemen, this completes my prepared testimony, I would like to defer to the next presenter, and be open to questions.

[The prepared statement of General Weiss follows:]

PREPARED STATEMENT BY BRIG. GEN. BERNARD L. WEISS, DIRECTOR CONTRACTING AND MANUFACTURING POLICY, HEADQUARTERS, UNITED STATES AIR FORCE

Mr. Chairman and members of the task group: I am Brigadier General Bernard L. Weiss, Director of Contracting and Manufacturing Policy for the Deputy Chief of Staff for Research, Development and Acquisition on the Air Staff. I am responsible for contracting and manufacturing policy formation and dissemination. I have spent 26 years of my Air Force career in contracting and manufacturing. I have served in all aspects of this business from buyer to contracting officer, from plant office chief to the Chief of Contracting at the Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio. Before moving to my present position, I served as Deputy Chief of Staff, Contracting and Manufacturing, Air Force Systems Command, Andrews Air Force Base, Maryland.

I appreciate the opportunity to meet with you today to describe the Air Force quality program. I will focus on the main components of our quality program and the challenges we face in obtaining compliance. Further, I will describe problems we have experience—in particular, with the Hughes Aircraft Company—and lessons we have learned.

At the outset, I must clearly state that government actions with regard to Hughes have been the result of consolidated and joint efforts of each military Service which has contracts with Hughes Aircraft in Tucson. As I discuss Air Force actions relative to Hughes, they are in fact the integrated efforts of all the Services and are executed by the Air Force, since we have cognizance of this particular facility.

Ultimate responsibility for product quality and the assurance that a given company's product conforms to contractual specifications and the statements of work, rest with the prime contractor. The government's role is to assure that the contractor's quality system is working and is reliable through periodic system checks, audits and selected physical inspection of products on a preplanned and random basis.

The cornerstone of our quality program is the military specification, MIL-Q-9858A, Quality Program Requirements. This document establishes the parameters of a quality system that a contractor must implement to ensure quality products are produced and delivered to the government in accordance with the terms of the contract. This military specification is the one most commonly invoked on Air Force and other DOD major weapon system contracts. It requires written procedures which assure quality through prevention of defects as well as through inspection of products and material in process. These written procedures must describe work operations in sufficient detail to ensure the task is correctly performed. They apply in all areas of contractor performance; for example, design, development, receipt of material, production, assembly, testing, packing and installation. The specification requires supplies and services provided under the contract to be controlled during all phases to assure conformance to contractual requirements. Further, it requires the contractor to maintain and use records as data essential to the effective operation of his quality program and make these available to the government. It applies to products and services performed at the contractor's plant or at any other source, including subcontractor plants. The specification emphasizes the importance of contractor actions to establish a timely method of preventing, detecting and correcting discrepancies at the earliest time possible.

I have summarized MIL-Q-9858A; now let me outline the Air Force program to oversee and enforce contractor quality activities. First we review the contractor's written procedures to judge their adequacy. Before they are accepted, the procedures must clearly describe the quality measures and other requirements and who is responsible for implementing them. Collectively, these company procedures encompass management functions at various organizational levels, i.e., at the corporate level, senior level, middle and line management levels. In large companies, system level procedures can number in the thousands and manufacturing and inspection level procedures can number in the tens of thousands. Also, manufacturing and inspection level procedures, which describe work operations and practices for the assembly of hardware, change relatively often and require continual attention. After the initial government review there is a continuing sampling process to review all procedures and the firm's compliance to the most current procedures.

The second component of the Air Force quality program is selected physical inspection audits and product tests to verify the adequacy of the contractor's quality assurance program. Inspection and testing is generally done on a sampling basis. Selected contractor inspection stations are visited at random, or in some cases on a mandatory basis by Air Force quality assurance personnel. Air Force inspection and tests serve to reverify and revalidate the results of inspections and tests performed by contractor personnel. Air Force actions measure the effectiveness of contractor procedures and the accuracy of recorded contractor measurements.

To understand the magnitude of this task, consider some statistics on the Hughes Aircraft plant in Tucson. At this facility there are more than 10,000 engineering drawings in use, requiring 18,000 work instruction packages. These are governed by 5,800 process specifications. Over 27,000 separate manufacturing tasks must be performed to produce hardware. There are 10,000 contractor inspection points and nearly 780 contractor employees performing quality assurance functions. This number includes approximately 700 inspectors and testers working on the factory floor.

Where there is a known or potential problem identified, the Air Force performs 100% inspection of the product until the problem is corrected through changes to the contractor's quality system. This means the contractor cannot process material beyond a designated point in the manufacturing process without first passing Air Force inspection. This procedure is also used in many situations to monitor critical characteristics. This level of inspection is necessarily kept to a minimum because it is manpower intensive. At Hughes Tucson, there are 35 Air Force quality assurance people, currently augmented by 17 additional personnel.

When deficiencies are found during procedures review or product inspections which the contractor has failed to detect, they are documented by the Air Force and reported in writing to the contractor for corrective action. The contractor is then closely monitored by the Air Force to make sure that the corrective action is effective and the deficiency is eliminated.

A final component of the Air Force quality assurance program is final acceptance of products for the government. This acceptance is based in part on records that indicate that the item has been inspected and tested as specified and meets the requirements of the contract. The contractor is responsible for producing a quality product and assuring the quality of that product prior to submission to the government. Considerable reliance is placed on the contractor's documentation in the acceptance process in addition to the Air Force data resulting from procedure reviews and product inspections which I discussed earlier, as well as specific acceptance criteria set forth in the contractual technical requirements.

Based upon the above, it can be seen that the contractor is responsible for the quality of his product. His responsibility starts with product design, carries through to producibility reviews and culminates in the manufacturing process. The government responsibility is to make sure that the contractor's system is functioning through system checks, and random and selected mandatory inspections and tests of product.

Having discussed the contractor's role as opposed to the Air Force's role in quality assurance, it might be helpful to describe the Air Force quality assurance program environment. The Air Force has under its cognizance operating locations at 24 of the major aerospace, missile, electronic and propulsion companies within the United States. Examples are companies such as The Boeing Company in Seattle, Pratt and Whitney Aircraft, Martin Marietta Denver Aerospace, Lockheed-Georgia, General Dynamics in Fort Worth, General Electric in Cincinnati, Northrop, Westinghouse Electric in Baltimore, TRW Electronics, and Rockwell International among others. At each of these facilities we have what is called an Air Force Plant Representative Office (AFPRO) located on-site.

AFPROs are responsible for the contract administration of government contracts at the plant where they are located, including those of the other military Services and other government agencies (e.g., the National Aeronautics and Space Administration) when requested. The AFPROs are manned with individuals with expertise in engineering, manufacturing, quality assurance, and contracting. These AFPROs are each commanded by a military officer, usually a full colonel. The AFPROs report to the Air Force Contract Management Division (AFCMD), at Kirtland Air Force Base, New Mexico. The Commander of the AFCMD reports to and works for the Commander, Headquarters Air Force Systems Command at Andrews Air Force Base, Maryland.

There are nearly 260,000 contractor people working on government programs on which AFCMD has contract administration responsibility. The number of contractor people at a facility ranges, for example, from a few thousand at AVCO System Division, Wilmington, Massachusetts, to over thirty thousand at the Hughes Aircraft Company complex within the area of Los Angeles, California. On the average, contractor quality assurance personnel represent approximately 10 percent of the total contractor work force AFCMD-wide.

An AFPRO on the other hand may have between 50 to 300 total people with an average of 33% of the AFPRO staff assigned to quality assurance functions. The average ratio between contractor quality assurance personnel and Air Force quality assurance personnel is approximately 20:1. The average ratio between total contractor personnel and AFCMD quality assurance personnel is over 200:1. Compare these ratios to the approximately 30,000 contracts administered at a face value of $138 billion on 130 major programs and one begins to have an appreciation for the enormous challenge that our quality assurance work force of 1300 faces in monitoring contractor activities.

The primary mission of an AFPRO is to support System Program Offices (SPOs) by administrating contracts awarded to the prime contractor. The SPOs, for example, Maverick, Phoenix, TOW, etc., set contract terms and conditions, determine the technical requirements, specify requirements for designing in quality, stipulate quality and test requirements, negotiate and award contracts, and review and approve waiver requests. The AFPRO then performs the administrative functions at the location(s) where the contractor performs the work. The relationship between SPO and AFPRO is a close one. There is usually daily communications between each office due to the many facets of on-going activities requiring coordination and often SPO approval.

Contractor quality systems have not been without problems. Let me discuss some causes of quality deficiencies such as those found at Hughes Aircraft in Tucson.

Product quality problems generally occur for a number of reasons; (1) quality is not the number one company objective; (2) lack of contractor management involvement and commitment to effectively correct manufacturing and quality problems early on; (3) attitudes shared by workers and management that are not conducive to building in quality; (4) giving priority to production schedules over quality; (5) insufficient emphasis placed on defect avoidance; (6) lack of clear workmanship standards; (7) large numbers of engineering drawing changes; (8) inadequate internal contractor audits; (9) lack of timely and effective training of new employees; (10) rapid increase in overall work load; and (11) inadequate work instructions and manufacturing planning documents.

With specific regard to Hughes Tucson, there were a considerable number of actions taken by the government to alert the contractor to the productivity and quality problems that existed within that facility. For example, between August 1983 and August 1984 an average of 80 deficiency reports were written each month by Air Force quality assurance representatives for procedural and hardware nonconformances, approximately 40 of which require the contractor's written response of corrective action taken. In addition, three audits were performed by the Army between May 1982 and October 1983 on the TOW program that also identified quality problems.

In October 1982 AFCMD conducted a Manufacturing Management and Production Capability Review (MM/PCR) that revealed manufacturing and quality problems. A follow-up MM/PCR by AFCMD in May 1983 found little progress made in correcting earlier deficiencies. This resulted in the Secretary of the Air Force meeting with Hughes corporate management to discuss a corrective action plan which was subsequently prepared and implemented by Hughes. However, the AFPRO continued to find quality system problems, and on 6 July 1984 the AFPRO Commander issued a letter of intent to disapprove the contractor's quality system unless full compliance with the provisions of MIL–Q–9858A were implemented.

After these repeated notices that gave Hughes the opportunity to fix the root cause of the problems, progress payments were suspended on 27 August 1984 for the Phoenix, TOW and Maverick programs. This action was a direct result of Hughes' failure to comply with the material requirements of the contract, specifically MIL–Q–9858A.

At our request Hughes has developed a Quality Improvement Plan designed to rectify the systemic and program unique deficiencies noted by the government. The plan consists of three separate parts. Part I is an executive summary that addresses the overall management approach for improving quality. Part II address specific improvements to be implemented on the various weapon systems programs, i.e., Maverick, Phoenix, TOW, etc. Part III addresses specific actions to be taken to make sure that quality is designed and built into weapon systems prior to commencement of production.

There are several lessons to be learned from the Hughes Tucson situation; (1) there must be a greater effort made to obtain a sincere commitment from contractor management for quality—prior to a major problem; (2) cost and schedule considerations must not take precedence over quality considerations; (3) deficiencies in a contractor's quality management system must be identified and corrected at the earliest possible time; (4) there must be correction of the root cause of a problem—not just the symptoms; (5) the waiver or deletion of contractual technical requirements must be thoroughly assessed to assure that product quality is not compromised; and (6) planning and execution of transition from development to production must be improved.

While these are the lessons learned at Hughes, there have been other lessons learned on a broader scale that I want to briefly discuss because they remain a concern to me. I have had the opportunity to visit Japan on several occasions, each time visiting Japanese industries and government agencies. Simply put—quality is their number one objective and we have seen the results of their efforts. It did not just happen; they made it happen by corporate, government and industry decisions and leadership.

If there was any one thing that impressed me about the Japanese, it was the fact that it was not uncommon for a quality assurance person to become the president of a company. Now I ask you, in American industry now often does this happen?

In 1979 I was privileged to lead an AFSC study on quality assurance. It was called "Quality Horizons". The study results clearly indicated improvements were needed both in the government and industry and recommendations were made as a result of visits to 66 government agencies and industrial firms in the United States, Japan,

Germany, Denmark, Norway and Belgium. Many of the recommendations of the study were implemented, others remain on-going, in addition to related initiatives, by the nature of the action. The following are some examples of areas which I believe must receive increased attention and which I continue to support and advocate: (1) raise the level of importance of quality assurance within government and industry; (2) continue to expand and improve upon the training of the quality assurance work force to keep pace with new technologies; (3) attract and retain highly educated and technically oriented individuals to fill civilian quality assurance positions; (4) increase the grade levels of our civilian quality assurance work force commensurate with their responsibilities and educational background; (5) maintain an effective and fully funded Manufacturing Technology program to provide new manufacturing methods and techniques throughout governments in productivity and quality of weapon system production; and (7) encourage broader productivity and quality improvement efforts such as the Industrial Modernization Incentives Program.

That concludes my prepared testimony and I will be pleased to answer questions you may have on this subject.

Senator QUAYLE. Thank you, General Weiss.

General Bunyard.

STATEMENT OF MAJ. GEN. JERRY M. BUNYARD, USA, COMMANDING GENERAL, MISSILE COMMAND, ACCOMPANIED BY S.J. LORBER, DEPUTY CHIEF OF STAFF, PRODUCT ASSURANCE AND TESTING, ARMY MATERIEL COMMAND; AND GEORGE WILLIAMS, DEPUTY PROGRAM MANAGER FOR THE TOW SYSTEM

General BUNYARD. Thank you, Mr. Chairman. As you indicated in the opening statement, I am the commander of the Missile Command in Huntsville, AL. I do have with me two backups, if you will. I have Mr. Sy Lorber who is the Deputy Chief of Staff for Product Assurance and Testing out of my higher headquarters, the Army Materiel Command, and Mr. George Williams who is the Deputy Program Manager for the TOW system.

I have a prepared text that, if it meets with your approval, I would like to submit for the record. What I would propose to do, sir, in the interest of time, is to focus right on the heart of the problem, the questions that both you and Senator Levin brought out. I would like to address them.

Senator QUAYLE. I would appreciate that. Without objection, your entire statement will be made part of the record.

General BUNYARD. Thank you, sir.

At your desk is a copy of about seven slides that I would like to walk through, if I may, to highlight what I call the key points of this discussion.

First of all, we need to identify what we are talking about in respect to the number of TOW missiles that are in our inventory, who has them, and so forth. How do we really check for reliability and quality? What has been our experience throughout the last several years in this area? What is our quality problem that we are here today to discuss? When did we find it? Last, but not least, what are we going to do about it?

On the first slide, entitled "TOW Missile Deliveries," I have broken out the three different types of TOW missiles that have been delivered to the Army, to the Marine Corps, and to foreign military sales.

We started production of the TOW system back in June 1968, and we first started the fielding in September 1970. Two product

improvements, the improved TOW, and the TOW-2, have come along subsequently. The improved TOW was fielded in April 1981, and the TOW-2 was fielded in July 1983.

You will notice now that those numbers would total up to somewhere in the neighborhood of 363,000-plus missiles. I might add that the current inventory, based on test firings, based on training and utilization by these other countries, we are now down in the neighborhood of approximately 276,000 TOWs that are scattered throughout the world today.

If I may, I would like to focus right in on the aspect of TOW reliability which both of you brought up as a major concern. There are really three ways in which we test for reliability and quality of the TOW missile system.

Regarding reliability, if you will refer to the TOW reliability chart, there are two things that we have been doing over the years, the first of which is the annual service practice. Our troops in the field have been firing these missiles over a period of about 14 years. In excess of 11,000 missiles have been fired, and you will note that the cumulative reliability has been 94 percent over these 14 years.

The next area that we look into for reliability has to do with the stockpile. In 1973, we withdrew from several lots that were produced in that period of time several hundred missiles and we put them in all kinds of different environments—the tropics, the arctic, the desert, and temperate.

Each year since that time, or since 1975, over the last 8 years, we take approximately 30 missiles out of that inventory. We tear down on an average of about 8 a year, and we fire about 22 a year, the purpose of which is to take a look at what is the life of this particular missile.

When we first developed the TOW, we thought we would have about a 5-year life-span. Through this program of stockpile reliability testing, we have been able to increase that up to at least 16 years. So the missiles that we are firing at this point in time average about 13.5 years.

So that gives you a feel of where we are with respect to the reliability. You will note on your chart that we have in excess of 93 percent cumulative reliability. Both of those numbers, the annual service practice as well as the stockpile, are very commendable numbers as far as reliability is concerned.

In addition, the other users, such as the Marine Corps and the foreign military sales, the information that we gleaned from their firings, their tests, substantiates the reliability that we have experienced here.

I might add further that when we started fielding the TOW-2, we did a performance demonstration in October 1982 through February 1983. We had a very successful demonstration. We fired 31 missiles, and with no failures. I might also add that the TOW system has, in fact, been fired in combat, and it was very successful.

Moving to the third aspect of this: How do we check the quality of a system that is coming off the line? What we have established over the years is that we do what we call a fly-before-buy. Let me

explain just a moment, if I may, what is a lot acceptance, and what is our fly-before-buy program.

From a lot, and normally a lot consists of about 1,000 missiles, we take 15 of those missiles out and we put them through all kinds of environmental extremes—hot, cold, shock, drop, et cetera. Then we take four missiles that are selected randomly, and we begin our firings. If we are successful in the firing of those four missiles, then the lot is accepted.

If there is a failure, we take five more missiles, and we fire those missiles. If we are successful in that, we accept the lot. If we have an additional failure, then we will take six more missiles, and that would bring you up to a total of 15 missiles that would go through the firing.

At any point in time during this course of acceptance testing, if we have three failures, the entire lot is rejected. It goes back to the contractor. He does the analysis, the rework, and the retesting at no cost to the Government.

Over the period of years, we have not had any final rejection of any lot. However, there have been two instances where the Army has stopped acceptance, and those I have listed on this chart. In June 1980, we did not accept a lot of missiles due to some erratic flights and some warhead dudding.

We found, when we isolated the cause, that it was due to damage to a printed wiring assembly because they were using the wrong tool on the production line. That was corrected. Hughes took those missiles, some 1,907 missiles, back into the plant, reworked and retested them. That was done in the plant at no cost to the Government.

The second instance of lot rejection occurred in August 1983 when we stopped our acceptance. We had two flight failures. The failure made was a wing that would not deploy. The four wings spring out once the missile leaves the launcher to stabilize the missile in flight. Binding was caused by a joint rotation when the environment was stressed. There was a binding in there.

We corrected in excess of 2,000 missiles, 2,707 to be exact. These missiles were in Europe. Hughes took it upon themselves, went to our depot in Germany, Meinz Army Depot, did the rework and the retesting at no cost to the Government.

Those are the two instances that highlight when the Army has in fact stopped acceptance. The contractor did in fact go in and do the rework and the retesting at no additional cost to the Government. Over the period of years, some 370 lots here passed acceptance, and there has been no final rejection in the 14 years.

More specifically, if we go to the next slide that talks about our quality review in October 1983, we are getting to the point that was in question a moment ago, the question of when did we find that we had a problem and what is it?

As General Weiss pointed out, the Air Force has the plant cognizance, and they are responsible for the surveillance and the quality performance at that plant. I might add at this point in time, in concert with the Air Force, we have made periodic quality assessments or reviews at this particular plant as we do in all of our other plants.

It was during such a visit in October 1983, five quality specialists, from my command, that we found a significant increase in the deficiencies over the previous year's review by my people. Looking here, what we are showing is that in October 1982, we had a total of about 12 deficiencies versus the 32 deficiencies that we had in October 1983. The hardware deficiencies were about the same, 4 versus 5, but the one thing that really jumped out was that the procedural problems that we found in October 1983, had increased significantly from 8 to 27.

What we are talking about here, as far as procedural nonconformance, deals primarily with people or the associated documentation in the production line. This is not a line stopper per se, since the deficiencies in the hardware did not show any alarm. However, the point being made here is that if this process continues, if they continue to be in nonconformance through the procedures, the people, and the documentation, it could in fact lead to a hardware problem, and we would address this as a cumulative risk that would be built up over a period of time.

The actions that we took at this point in time, working with the Afpro and with the contractor, were to make the necessary notification to the contractor through the Afpro, and request the contractor to respond. We also asked that the Afpro validate that particular response. A letter of extreme concern was forwarded to the management at Hughes.

We went back in February 1984, to verify that in fact those fixes had been implemented, and the production line was progressing and proceeding in the manner that it should have been all along. I might add that prior to my team going back in there, the Afpro had gone in and validated the connections.

Taking a look at our perspective in the February timeframe of this year, 1984, we felt that this was not a systemic problem because, to the best of our knowledge, and I am speaking of the Army, there was not a problem with either the Navy or the Air Force. Remember that February was prior to the June teardown that the Navy got into with the Phoenix missile.

We felt at that point in time that the contractor had taken adequate measures to correct those specific problems that we had outlined in October of the previous year. In fact, from the period of December 1983, through February 1984, we had a very successful fly-to-buy program where we had achieved 97-percent reliability.

During this course of the October 1983, through February 1984 timeframe, we requested that the Afpro incorporate 71 mandatory inspections.

I think that the key lesson learned here—and I will be upfront, it is a key lesson that not only the Army learned, but all the services learned, and hopefully the contractor learned, because he is the key person in this event—is that we collectively, if you will, did insufficient analysis to isolate what was the root cause.

What we tried to do at that point in time—when I say, "we," I am talking about the whole process that went on here, specifically the contractor, though—was to solve the problems one at a time, instead of a more proactive approach of doing a complete job of analyzing the situation, and then keeping the pressure on to get

the entire system fixed. I think that is perhaps the biggest lesson that all of us have learned in this affair.

More specifically, if you will go to the next chart, based on the teardown that the Navy did in June 1984, the TOW project manager, along with Hughes, conducted a similar teardown of the TOW missiles. This was done in July 1984.

As you indicated before, Mr. Chairman, this consisted of a teardown of four TOW missiles. I might indicate that one was a complete round, and the other three were without warheads and without the rocket launch motors which we were not focusing on at that point. We wanted to find out what in fact was happening at the Hughes plant.

In our teardown—I am going to be more specific here, as opposed to what the Air Force found in the number of deficiencies, because we got down to the nitty-gritty and we were very specific—we had a total of some 79 findings, broken down into what I have classified in eight different categories.

You will see them on the chart. They talk about workmanship, and an example of that, while there was no particular problem as far as performance was concerned, scratches on metal surfaces and things of that nature, to include the loose wire.

There are two others that I would like to refer to. The next one had to do with what I call design, we had six deficiencies there. This does not mean that there were defects in the design of the missile. Let me explain what I am talking about in respect to design, and I will cite one example. A screw that when seated was recessed too deeply, but has in fact been installed as required. That is what I am calling the design of how we put that system together, if we put it in that particular category.

The other area that I would like to talk to had to do with the category of instructions. Senator Levin, I will address your particular point that you brought out about the 10,000 missiles that we have in the inventory. The instructions, what I am referring to here is failure to follow instructions, failure to follow the procedures, the process that had been laid out on the line.

More specifically, in the form 47, the Command Management Systems Evaluation Program, which is the one to which you referred, the deficiency report of July 17 referred to the sampling inspection. This addresses what we call skip lot sampling procedure, and let me explain what that is.

A skip lot sampling procedure is designed as such, and it is used throughout the different factories. The requirement is that we do 100-percent sampling for three consecutive lots. If there are no discrepancies or deficiencies found, then the contractor has the authority to skip lots and go to every 10th lot or to go to every 6 months, whichever way he wants to go. However, the key to this thing is that the contractor must certify that he has complied with the technical data package specs that have been called out for in that particular program.

The problem that Colonel Hagan brought up here in his report simply means that there was a lot that came through, that did not need to be sampled, but the contractor had not in fact complied by providing that certification. Therefore, the system was stopped.

The problem really centered around a little terminal that is on a circuit board that goes in our electronic unit. The problem was what type of coverage, on plating, if you will, was being utilized, was it tin or tin/lead. They were using something different from what it was supposed to be.

What we did collectively within the Government, and with the contractor, was to take that sample, and do a very thorough analysis—including my laboratory people out of the missile command—to find out, did this really make any difference. The "so what" question, if you will.

We went in and took a look, and we found that it really had no impact on performance. It could be accepted. So subsequent to that, an engineering change proposal has been submitted, it will be accepted, and this will be utilized.

I think, Senator Levin, the answer as to what is the status of those 10,000 missiles in the field is that they are in fact good missiles. They have been fired, and they will continue to be fired, and they are good, sound, reliable missiles.

In addition, what we have done, we are getting away from the skip lot type of sampling, and are going to go to 100 percent. In fact, that is what has been incorporated. No more of the skip lot sampling. I might add, once again, that the contractor has paid for the cost of analysis in all of this.

Going back to the categories, there is one other thing that I would like to point out. The most significant finding, out of the whole 79 that we came up with, is in the thing that we call the capstan, which is inside the launcher. It holds on to the wires as they go out.

What happened was that the capstan was not flush with the inside of the container. There was some concern at that point in time as to whether that would have an impact on the performance of the missile. The answer to that is, not necessarily so. In all of the missiles firings that we have had and the tests, we have found that this has had no impact.

However, we have some 7,000 missiles that are currently in storage at Hughes. We are going to take those missiles back into the factory, and that is going to be corrected. In addition we have several thousand that are currently in the field in Europe. I will talk to this in a moment, but just to get ahead of myself, we are starting a sampling program which will consist of a teardown and flight of those missiles that we have sent to the field. The first type of system that we will be checking will be these that are in Europe, we will go in and verify.

If we find that there is a performance problem, then the contractor will once again go to Meinz Army Depot and make the necessary correction. Right now, we do not consider it a performance problem, but just to make sure, we are going to do that.

Now the question of what are we doing as far as future Army acquisitions, and I think that General Weiss has brought out in his testimony, and certainly in mine, all of the actions that are currently ongoing as far as the triservice actions are concerned out at the plant. But, more specifically, in addition to all of those things, what the Army is going to do is to maintain additional Government inspection points on the production line until we have an

adequate confidence level that we are getting, good, sound, quality missiles off the line. This is a full time inspection station of eight specific points that will be incorporated once the production line goes on or picks up.

The second thing that we are going to do is increase the Army surveillance. This will be my people coming out, my product assurance directorate, as well as my systems engineering directorate at the Missile Command, to increase our frequency and our indepth surveillance of what is going on in the plant.

We, for example, will have a review, beginning the week of October 29, to assess the progress thus far as to what is going on in the plant. I plan to go out there myself on the 7th and 8th of this next month. We will have also a full review prior to the submission of that first lot, once they get started up, before we accept the missiles in December of 1984.

In addition to that, I am working in concert with the Air Force and the Afpro to put out at the plant a technical liaison officer to be my point of contact, on a day to day basis. That is not to say that I am going to reduce my quality specialists going out to the plant, because I will keep that up as I do in all of my other plants.

In addition to these, we are going to tear down two missiles per lot as they come through the fly-to-buy program, and fly the rest of them. I explained to you a few moments ago how our lot rejection process worked. In addition to that, we are going to tear down two missiles out of each lot, and that will give us a better sample of what we are having.

In addition to the stockpile reliability testing that we have been doing of those lots that we set aside back in 1973, we are going to go in and take a look at other lots, other years, by going in and doing teardown and flight test. These will be additional measures that we will take once the production line starts up.

I would say in summary, sir, that we feel confident—the Army feels confident that Hughes has taken the recessary steps to correct the situation and they will deliver a quality product. At the same time, I can assure you that the Army assessments specifically, not only from my headquarters but from my higher headquarters, will increase in frequency and in depth to assure that our soldiers have reliable weapons.

Sir, that concludes my testimony. I will defer to Commodore Finneran.

[The prepared statement of General Bunyard follows:]

PREPARED STATEMENT OF MAJ. GEN. JERRY MAX BUNYARD, U.S. ARMY

Mr. Chairman, members of the Senate Armed Services Committee Task Force on Selected Defense Procurement Matters: I am Major General Jerry Max Bunyard, Commander of the U.S. Army Missile Command, based at Redstone Arsenal, Alabama. I am responsible for U.S. Army missile and rocket weapons and related equipment. That includes research, development, acquisition and support of fielded systems. We procure missiles for other services which also use Army missiles, and through the Security Assistance Program, Army missile and rocket weapons sold to the armed forces of other nations.

I am here today in response to your request for an Army representative to discuss with you quality and workmanship issues which have arisen in the production of TOW missiles. The TOW system is one of many managed by my command. I am the head contracting authority for the TOW weapon system. I have with me Mr. S. J.

Lorber, Deputy Chief of Staff for Product Assurance and Testing, U.S. Army Materiel Command, and Mr. George Williams, the Deputy TOW Project Manager.

The TOW missile is produced in a government-owned plant at Tucson, Arizona, by the Hughes Aircraft Company. Other components of the TOW system are made for us elsewhere by other contractors.

TOW is a portable, heavy antitank/assault missile weapon system capable of operation from the ground, from lightly armored or unarmored or armored vehicles and from helicopters. The Army uses it in all those applications. The system consists of a guided missile and a launcher. It is designed to defeat tanks, fortifications, and other materiel targets.

The name, TOW, is an acronym derived from words which describe the principal operating features of the missile. It is a tube-launched, optically-tracked, wire-guided round of ammunition. The launcher includes the hardware for weapon delivery with provision from initiating missile flight, for tracking the missile during flight and for controlling the flight path of the missile via guidance signals transmitted automatically over a wire link connecting the missile with the launcher.

The TOW missile is considered a "wooden round" of expendable ammunition. By that, I mean no maintenance or repair is done in the field.

There are three configurations of the TOW missile. All have the same basic airframe, aerodynamic control system, command wire link and missile electronics. Without going into technical detail, let me describe the essential difference:

1. The basic TOW missile has been fielded in two versions with ranges of three kilometers and three and three quarters kilometers. We achieved the greater range by adding more wire to the bobbins carried in the missile. It has a 5-inch diameter, high explosive, shaped-charge warhead.

2. Improved TOW has an improved 5-inch diameter warhead with a nose mounted probe that extends in flight and detonates the warhead at a greater standoff distance from the target, improving armor penetration. The missile range is 3.75 kilometers.

3. TOW 2, the most recent version, carries a 6-inch diameter warhead with a nose probe. Modifications were also made to the guidance system which improved performance in battlefield conditions—such as smoke and countermeasures—and also makes it possible to fire at night or in periods of reduced visibility using an electro-optical infrared night vision sight which is mounted on the TOW 2 launcher. The missile range is 3.75 kilometers.

Development of TOW began 21 years ago—in 1963—with award of a cost plus incentive fee contract to Hughes Aircraft Company.

Full scale development was initiated in 1964. The first production contract with Hughes was signed in June 1968. Fielding in the U.S. Army began in September 1970.

In a successful effort to reduce the overall cost of the system, the Army qualified Chrysler Corporation as a second source for production of the missile and then competed Chrysler and Hughes. Chrysler shared in production of the missile with Hughes from 1969 through 1971. As part of the acquisition strategy, the Army then conducted a winner-take-all competition for what was then believed to be the remainder of the production requirement. Hughes won that competition and in FY72 was awarded a 4 year, multi-year contract on a firm fixed price.

Hughes has continued to produce the missile since then working on firm-fixed price contracts.

Improved TOW and TOW 2 evolved as product improvements to basic TOW in the late 1970s. Improved 2 went into production in FY80 and fielding began on schedule in April 1981, TOW 2 went into production in FY81. First production deliveries cam in November 1982. Fielding began in July 1983.

TOW 2 is the only version now being produces for the U.S. Army.

The two system is noe deployed by the U.S. Army in three overseas theaters and with units throughout the United States. TOW is also the primary heavy antitank weapon of the U.S. Marine Corps. It is used by the Armed Forces of 38 other Nations.

Through August 1984, Hughes aircraft company has delivered more than 350,000 TOW missiles. More than 150,000 have gone to the U.S. Army. The U.S. Marine Corps has received 20,600 missiles. The remaining missiles have gone to other nations under foreign military sales agreements.

Despite the problems of poor quality control and workmanship recently brought to light in Hughes Aircraft Company production operations at Tucson. The Army is confident that the TOW missiles our soldiers have are reliable weapons that will work. Let me tell you why.

A significant body of data has been collected over the long life of this program which verifies that TOW is a good missile and the system can and will do the job the Army wants it to do. Our confidence is based on these facts:

1. In 1973 we set aside a quantity of missiles produced in that year and stored them in four locations which represent environmental extremes. Beginning in 1975 we took at least 30 missiles from that stock, conducted teardown inspection testing every component and fired the remaining missiles. We have done that each year since, averaging eight missile teardowns and 22 firings annually. Reliability results have been consistently above 93 percent.

2. We have data on more than 11,000 TOW missiles fired by American soldiers over the last 14 years. Demonstrated reliability of the two missile in those firings has exceeded 92 percent. And by that I mean at least 92 out of 100 missiles fired, have ignited, flown, guided correctly and hit their targets. When live warheads were fitted, the warheads detonated. Other users have fired about the same total with similar results.

3. TOW missiles were fired in combat in Vietnam by American forces in both ground and helicopter applications and since then have been fired in combat by other users. Results achieved in battle were outstanding.

4. We conducted a performance demonstration test of production TOW 2 missiles between October 1982 and Fedruary 1983 before fielding TOW 2 with the U.S. Army. Thirty one TOW 2 missiles were fired. There were no failures.

5. Before a production lot of missiles is accepted by the Army, missiles selected at random from that lot are fired and must demonstrate satisfactory performance. A normal production "Lot" is a quantity of 1,000 missiles. The performance acceptance criteria for this program we call fly before buy requres that 15 missiles are selected and subjected to environmental extremes (hot and cold temperature) with drop and vibration conditioning as well. Four are then fired. If all four missiles are successful, the lot is accepted. Should one of those four fail, then five more missiles must be fired for a total of nine. Should one additional failure occur in the firings of the next five missile, then six more missiles must be fired for a total of 15. If another missile fails (a total of three failures in 15 firings) the entire lost is rejected. Should three failures occur at any time in the test sequence, the entire lot is rejected. Rejected lots must be screened or reworked at the contractor's expense. In the 14 years TOW missiles have been in production, there has not been a single instance of final rejection of a production lot.

There have been two instances when the Army stopped acceptance of TOW missiles.

In June 1980, during fly before buy flight testing, we experienced warhead duds and erratic flights. The cause was determined to be damages to a printed wiring assembly in the missile electronic unit. The damage was caused during missile assembly on the production line because an improper tool was used. The problem was operator-related and isolated to a total of 1,907 missiles in three lots. Proper tools were provided to all operators and the missiles were reworked and retested. All costs were paid by Hughes Aircraft Company.

In August 1983, we experienced two flight failures, we found the cause to be a missile wind binding in its wind slot. There are four small wings on the missile which pop open as it leaves the launch tube and stabilize the missile in flight. The binding prevented the wing from fully extending to the flight position. In that instance a fix was established, 2,707 missiles were screened, reworked and retested. Hughes Aircraft Company paid all costs.

Our prior experience with Hughes Aircraft Company thus had been that in these and less serious instances when deficiencies were found, Hughes moved promptly to correct them at their expense and corrective action was confirmed by the Air Force representatives at the Tucson plant.

As you know, the Air Force has plant cognizance at Tucson and is responsible for surveillance of the missile production activities there and the contractor's quality performance. The Army also monitors the contractor's performance. We also make periodic visits to the Tucson plant to review production operations and quality management.

It was during one such review in October 1983—an annual hardware oriented survey by a team of five quality specialists from my command—that we found a significant increase in deficiencies. There had been 12 found in the 1982 survey. This one, in 1983, found 32. Specifically, the 12 found in the 1982 included four related to hardware and eight related to procedural problems. In October 1983 our team found five hardware related problems and 27 instances of procedural noncompliance. In our judgment, none of these items were show stoppers that would require a halt in acceptance. We did consider them serious and we initiated immediate corrective ac-

tions by Hughes Aircraft and follow up by the air force personnel at the plant. The TOW project manager requested and received from Hughes aircraft a status review of corrective actions at a quarterly review with the contractor on November 7, 1983. We made a follow up visit to the plant in February 1984 and found that all action items had been completed.

In hindsight, we should have done more. The number of deficiencies we found may—and I say may because I cannot be sure—may have pointed to a larger, systemic problem. We did not look for that. Instead we assured ourselves that the individual deficiencies we found had been corrected and stopped. The fly before buy firings conducted from December 1983 through February 1984 resulted in but one missile failure in 33 flights. We believed those good results indicated extra management attention was being given to the problems found in October 1983.

What we now recognize as a systemic problem began to surface in June 1984 when the Navy conducted a teardown inspection of Phoenix missiles manufactured by Hughes Aircraft Company at Tucson. The navy found workmanship and quality problems and decided to stop acceptance of the Phoenix missile.

As a result of the navy findings, Hughes Aircraft management and the Army TOW project manager did a similar review of TOW production. During July 1984 Hughes and the Army conducted an audit to determine compliance to quality workmanship standards, manufacturing planning procedures, product assurance and test procedures and instruction followed or given to workers. The audit included a teardown inspection of four TOW missiles, one complete round and three others not yet fitted with warheads and rocket launch motors. We had a total of 79 findings. Specifically: 22 categorized as product discipline, for example, things that should have been done had not been done; 18 categorized as workmanship, for example, scratches on metal surfaces; 13 categorized as manufacturing methods, for example, something done or used in the manufacturing operation damaged hardware; 11 categorized as instructions, for example, failure to follow established procedures; 6 categorized as design, for example, a screw that when seated was apparently too deeply recessed but had in fact been installed as required. Let me interject here that the use of the word design as a category can be misleading. It does not mean we found defects in the basic design of the TOW missile. Continuing: There were six findings categorized as vendor, for example, a part procured by Hughes from a supplier that was improperly marked and three miscellaneous finds.

In summary, we found poor workmanship, product discipline and noncompliance with procedures. The majority of these deficiencies were people problems, an indication of inadequate training or inadequate procedures. Corrective action was initiated.

While we were conducting our review on TOW, the Air Force conducted a product review and assessment of production hardware on all three major missiles in production at the Tucson plant—the Army TOW, the Navy Phoenix and the Air Force Maverick—to determine if they met drawing and specifications in the contracts. The Air Force findings revealed deficiencies that appeared systemic in the production operations for all three missiles.

Air Force, Navy and Army representatives met August 2, 1984, to review the Air Force findings and determine a joint course of action. It was decided that Hughes Aircraft was not in compliance with contractual quality and workmanship requirements. The course of action decided upon was a 90-day cure notice to Hughes Aircraft company, implementation of mandatory government inspection points on the production line for each missile and a detailed quality improvement plan to be submitted by Hughes Aircraft to the government by September 1, 1984. Hughes met that deadline.

On August 8, 1984, Hughes Aircraft Company notified the government that Hughes had decided to temporarily stop all missile production. When Hughes stopped production, we initiated action to stop progress payments. The government formally notified Hughes Aircraft on August 27 that all progress payments were stopped.

Where do we go from here? Hughes Aircraft Company has approached this problem with a positive attitude and is in the process of making changes that are needed to solve it. They have changed plant management, done extensive reviews of production operations and instituted corrective actions. Eight mandatory government inspection points have been established along the TOW production line to assure positive results in quality control. The Air Force has a detailed plan to monitor Hughes actions to improve quality and workmanship.

Resumption of production and progress payments is contingent on government acceptance of a restart plan and securing an agreement with Hughes Aircraft Compa-

ny that Hughes will bear all costs associated with the work stoppage. We hope to have those issues settled soon.

I will continue to monitor activities at the plant closely. A plant visit and survey by a team from my command will be conducted when production resumes to assure that problems previously identified have in fact been corrected. I have directed my people responsible for product quality to increase both the frequency and the depth of reviews not only at Hughes but in other Army missile contractor production operations as well. We intend to also take additional missiles from our stock and assess their reliability through teardown inspection and firing. When production resumes, we will tear down some of the missile taken out for fly before buy and continue to do that until we are satisfied.

I am satisfied that we have Hughes Aircraft Company management focused on quality, that they are taking the steps necessary to correct the situation and that they and their workforce will deliver a quality product to us when they resume production.

STATEMENT OF COMMODORE WILLIAM J. FINNERAN, USN, ASSISTANT COMMANDER FOR SYSTEMS AND ENGINEERING, NAVAL AIR SYSTEMS COMMAND

Commodore FINNERAN. Good morning.

I appreciate the opportunity to appear before this committee today to discuss our Quality Assurance Program in the Navy.

I would like to identify two additional backup witnesses. You had mentioned that Capt. William C. Bowes, the program manager for Phoenix is here: it is quite true that he is here. Dr. Allen Somoroff is the Quality Assurance Division Director, and he is here. He works for me in the Naval Air Systems Command. Mr. Mike Laversa is also here, and he heads up the Quality Assurance Division, working directly for Mr. Willis Willoughby who was mentioned earlier.

I am the Assistant Commander for Systems and Engineering at the Naval Air Systems Command, my responsibilities include the management of the naval aviation quality assurance program. Our policy is to have an appropriate quality assurance program for all products and materials which we develop or procure. This program is the primary vehicle for assuring that high quality equipment and weapon systems are delivered to the fleet.

Our quality assurance program has many elements. The specific program activities, of course, vary with the nature and life cycle phase of specific products. Clearly, quality issues are best addressed early in the life cycle of a product. Key elements of our program include establishing sound contractual quality requirements and monitoring both supplier practices and the product itself for conformance with established requirements.

For major products, Government quality assurance representatives provide resident coverage at the site of manufacture. Where a naval plant representative (NAVPRO) is the onsite Government representative, the quality assurance program is administered by the NAVPRO quality organization.

The NAVPRO's quality assessment program examines individual plant operations and the contractor's quality system in total. Audits, which are the heart of the assessment program, are made to evaluate the effectiveness of the contractor's quality program in satisfying specified product requirements.

NAVPRO product verification audits entail significant hands-on inspection by Government personnel, and emphasis on such hard-

ware inspections is being increased. Management audits examine the contractor's overall quality program as it applies to all functions. This involves scrutiny of the contractor's organization, including his quality planning, work instructions, record keeping, corrective actions, drawing and change controls, metrology, control of nonconforming materials and control of subcontractors.

For many Navy weapon systems, resident Government representation is provided by Air Force or Army plant representatives in which case the onsite Government quality functions are performed by these organizations. In other cases, Defense Contract Administrative Services personnel provide the onsite coverage. In conjunction with the DCAS and NAVPRO's, we have performed 57 special product oriented surveys and 25 quality reviews during the last year.

An example of special audits is our electrical/electronic surveillance and technical evaluation program. This program entails specific inspections of electrical wiring and electronic installations on each model aircraft, randomly selected at the contractor's site by nonresident audit teams. Each model aircraft is subjected to such an assessment at least once every 18 months. The findings provide one measure of the contractor's and the Government's quality assurance program.

Although our quality assurance program is extensive, periodic problems serve to highlight the need to continually pursue ways to increase our effectiveness.

Regarding recent quality issues, the committee has indicated a specific interest in the events at Hughes Aircraft Co., Tucson. I would like to briefly describe our perspective of these events.

In preparation for a decision on increased production rates, the Navy performed a teardown inspection of an AIM-54C Phoenix missile at Hughes, Tucson, on June 6 and 7, 1984, to make an assessment of as-built quality. The teardown inspection teams, composed of Navy quality assurance and technical specialists, observed numerous quality and workmanship problems which violated contractual requirements and acceptable practice.

On June 22, 1984, the Navy stopped acceptance of Phoenix missiles. Two additional AIM-54C missiles were disassembled and inspected by a Government team at Hughes, Tucson, on June 26 to 28, 1984. The observations were much the same as the earlier inspection. Also, specific manufacturing areas and processes were reviewed at that time.

The observed quality deficiencies were found to stem from a range of problems related to work instructions and workmanship criteria, training, manufacturing process controls, in-process inspection, facilities and design-induced producibility difficulties. However, the most important cause of the problems was insufficient contractor management priority for quality.

These findings indicated a need for a major corrective action effort by Hughes to improve quality by identifying and rooting out the systemic causes of the problems. The need for corrective action was supported by the audit findings of the Air Force Contract Management Division.

In early August 1984, Hughes suspended all assembly operations at Tucson to focus on a reexamination of its quality practices and

the improvements needed to deal with the specific problems found in the hardware inspections and to correct the underlying causes of the quality problems.

Hughes' commitment to corrective measures of its Tucson operations are incorporated in a quality improvement plan for the Tucson plant as well as individual corrective action plans for each program. The Navy has received the corrective action plans for the Phoenix missile and the angle rate bombing system, both of which are produced at the Tucson site.

Some corrective measures are now complete, others are partially in place, and some are in the planning stage. Many specific actions are fortified by policy changes to instill and maintain the discipline needed to prevent recurrence of the problems. As an example, all changes in work planning instructions will not only be reviewed by the engineering personnel but will also be verified by validation of hardware produced by representative factory operators.

As work resumes, mandatory Government inspections in accordance with newly certified inspection criteria will be in place to validate that the hardware is, in fact, of high quality and satisfies all Government requirements.

Additional improvements are to be progressively made in facilities, worker training and motivation, supplier quality control, and the full implementation of defect reduction control and management information systems. With these improvements and a continuation of the management attention to assure high quality, measurable progress should be made toward the best approach to quality which is to build it right the first time. We must build quality in during the manufacture.

We intend to closely monitor the progress of the quality improvement plan through review of required progress reports as well as onsite evaluations with the quality of the hardware standing as the critical index of success. We believe the corrective actions completed and planned, when faithfully executed and adhered to, will provide for higher quality and more efficiently produced products.

Overall, the experience with Hughes has certainly heightened our own awareness and reinforced our commitment to further strengthen our quality assurance program, In this regard, we have already committed to an intensified quality audit effort, development of an improved data system to facilitate consideration of contractor quality performance in contract awards, imposition of mandatory contractual requirements reflecting best manufacturing and test screening practices for all electronic and electrical equipment, and an increased recognition of the need for early consideration of producibility issues in equipment development.

Sensible competition and use of warranties can also be expected to provide incentives for delivery of high quality products. This is an area in which we intend to be successful.

Thank you, sir.

STATEMENT OF C. BLAINE SHULL, VICE PRESIDENT FOR MANUFACTURING AND MANAGER OF TUCSON ACTIVITIES, HUGHES AIRCRAFT CO.

Mr. SHULL. Good morning.

I am Blaine Shull, recently assigned, and currently responsible for the Tucson site production activities of Hughes Aircraft. I appreciate the opportunity to appear before you to address quality issues and to report on what is going on at our Tucson facility.

My remarks will describe quality problems as we see them, actions we are taking to resolve these problems, and lessons we have learned from this process.

In case you are not familiar with our Tucson operations, let me size them for you. We occupy almost 2 million square feet, supplied about equally by the Air Force and Hughes, and employ about 6,500 people. We are in production on TOW, Maverick and Phoenix missiles, as well as the angle rate bombing system. In addition, work is underway on early models of AMRAAM. Our products are fielded by the Army, the Navy, the Air Force, and the Marines.

Throughout this presentation there are various attachments called out, and I believe you have a copy of this that you may refer to as you choose.

As you undoubtedly know, over the last few months, several Government audits were made of our operations and of the quality of hardware being built in our Tucson plant. The reports of these examinations and resultant administrative actions taken by the cognizant Government agency overseeing our activities caused us to look harder at ourselves. What we found, in general, confirmed findings of the Government's reviewers: Our operating disciplines were not what they should have been.

We do differ in degree regarding these findings, but believe that debating the differences would be nonproductive. We have chosen to direct that energy toward improvement. We can and will do better.

The quality problem—we believe the primary quality problem to be one of internal production operations that resulted in reduced yields and acceptance rates, longer build cycles and higher costs. Despite mutual concern over the reinspection results of completed products, we have found no evidence that our products in the field are not performing to specified levels. Even so, we feel that higher quality internal operations will produce an even better product for the field.

While this is only a general problem statement, as I report on our improvement plans and lessons learned, the principal factors contributing to the basic problem should be clear. I will also include data that leads to our confidence in our fielded products.

We have an extensive quality improvement plan at Tucson. To address the quality problem, we have developed and are continuing to expand a broad-quality improvement plan. It involves fundamental changes in our management approach. Our plan directs a number of actions toward a single major goal—defect free operations.

While we at Tucson represent only about 10 percent of Hughes Aircraft Co., we have received guidance and firm support from the corporation. Earlier this summer, our chairman and president jointly set down a policy of quality first for Hughes. The policy recognizes potential priority conflicts with other objectives, but insists upon quality first in the conviction that other traditional business

objectives will follow successfully. It also expresses confidence that our people want to deliver top quality products to our customers.

This statement followed an earlier commitment to quality and productivity that adopted five specific objectives for Hughes for the decade, and they are:

(1) Design for productivity—make it easy to build.

(2) Apply technology to the process of designing and building high technology products.

(3) Make total quality a way of life.

(4) Release the full capabilities of our people.

(5) Make suppliers full members of the Hughes' team.

In restructuring, we have firmly adopted methods that break with tradition: (a) To return responsibility for quality to each performer, as distinct from having a quality control department acting as a referee; and (b) to concentrate on process controls.

This focuses on building good quality in rather than inspecting bad quality out. We have strengthened inspection control as an interim supplemental necessity, but intend to increase emphasis on the building-quality-in approach as rapidly as our demonstrated performance allows. We believe it is the competitive way of the future.

With this direction and backing, in August we voluntarily suspended assembly and related inspection and test—and only those operations—that involved about 15 percent of the people at Tucson. All other operations continued, for the primary focus of our shortcomings was in the assembly area. Our improvement plan, however, applies to all operations within the plant.

We directed all employees, whose assembly work was suspended, to examine critically work instructions, tooling, and worker understanding and capability. Each assembly supervisor was assigned a team of manufacturing and design engineers to help in the review and with subsequent modification.

We set down criteria for resumption of assembly operation. Each supervisor was to declare his team to be ready to restart, part number by part number, and to have his readiness confirmed by his manager and quality assurance.

We are correcting systemic problems through a redirection of management, more discipline in operations, an indepth self-examination, and an upgrade of all operations.

In the management line, we have restructured our organization and the management staff. New quality policy and oversight responsibilities have been assigned within the missile system group—the portion of Hughes to which Tucson reports. I have joined Tucson in a new position, responsible for all Tucson site activities. Reporting to me is a new product quality director responsible for audit, inspection, and test, and for developing the more analytical total quality approach.

We have drawn upon our space and communications group for a new manufacturing division manager who helped develop the quality practices for satellite production where success is absolutely dependent upon defect-free hardware.

Assembly people whose hardware building tasks were suspended were immediately assigned to participate in an indepth review of their operations. They reinspected their own recently produced

hardware. They critiqued work instruction documents for clarity and conformance to engineering designs. Work instructions, as you know, translate engineering drawings into terms that can be used for repetitive production operations.

Assemblers, likewise, determined whether they had been building hardware precisely as required by those work instructions.

The magnitude of the task was large. In our plant, we operate to more than 1,600 different specifications, over 10,000 engineering drawings, and over 3,600 assembly work instruction documents for more than 1,000 different subassemblies.

The results of this self-review are thousands of requests for changes in work instructions and engineering drawings. Many of these changes are record changes, that is, not substantially affecting hardware performance or reliability, but not precisely correct. Examples are: A bracket call out on a different drawing level indenture than the indentured level at which installed. Another example is removal of a potential ambiguity as to which type of masking tape to use on a specific operation.

Some requests call for a lower cost design such as including the part number designation as an integral part of printed wiring board master artwork rather than subsequently stencilling it on. Another suggests the use of a tool that trims leads more precisely for semiautomatic insertion of components into a printed wiring board.

We have incorporated appropriate changes, and updated nearly half of our work packages. The balance will be completed next month.

A major conclusion of this review is the need to accelerate application of computer-controlled, graphically presented paperless work instructions for general assembly use. With the help of Government advice, and associates in Hughes and elsewhere in industry, we have raised the priority of that effort. We have also installed requirements for "prove-in" of new work instructions before their release to the production floor, and for training of the assembly engineers who prepare work instructions.

Another major effort is the application of defect reduction process controls. We have analyzed our overall manufacturing process—from buying, to metal parts fabrication, to printed wiring board fabrication, to microelectronics production, to circuit card assembly, on through to missile assembly and test—and we have selected about 150 key control points.

We are applying defect data collection and analysis to each such point together with specific corrective action plans and forecasted improvements. As well as being the basis for management action, these will be posted in appropriate work areas so that those involved can plan and track their own progress. We are indebted to industry associates and some experienced Government advice on this issue also.

We have made major commitments to upgrading of facilities. A new ultra-modern microelectronics facility went on line last year. We are accelerating the completion of a new extra-clean circuit card assembly area for move-in by the first of November of this year. This features better lighting, simpler product flow, conductive

flooring and work surfaces to prevent electrostatic damage to sensitive semiconductor devices and isolation of critical processes.

In addition, we have committed, and in several cases already have on line, significantly upgraded assembly areas for each of our production programs. Equipment is on order for a substantial upgrade of receiving test capability to be available starting in January of next year. About three-quarters of our assembly areas are being upgraded in the 1983–85 period. Over 40 percent of our major equipment items will be upgraded in the 1983–86 period.

We have a 5-year, from 1983 to 1987, production capital appropriation plan of about $250 million. We are on-track through 1984 with $80 million already obligated. This includes a $20 million-plus investment for a 190,000 square-foot assembly plant at LaGrange, GA. Initial contracts for that plant have been let.

Training and learning is another area of major attention. We have recertified our assembly and solder certification school and instructors. Content has been added to classes for operators and inspectors. We are adding our own self-certification classes for electro-mechanical assemblers and special process equipment operators. Our training school, which has been enlarged by a factor of almost four, is recertifying existing operators as well as training new ones.

One of the noted deficiencies in our system was the effectiveness of independent audits. We now have an audit system that will continue the review and reporting process on which we have been concentrating for the past 2 months. Four different organizations divide the auditing of operating systems compliance, corrective action effectiveness, hardware quality, workmanship, manufacturing floor disciplines, work instructions, hardware disassembly, and contract requirements flow-down. These audit reports will go to management for corrective action as necessary. Several new trial audits have already been made to refine the audit procedures.

We are updating our entire series of management, engineering, and operating procedures. Part of the update is to reflect a major reorganization made near the beginning of this year. All told, over 400 procedures are involved. Many have been completed, and the rest are due from now through December. That major effort was started early in this year.

Even though moving toward built-in quality is our predominant approach, we recognize the need for assured inspection effectiveness. Suspension of assembly operations allowed operators to perform self-inspection, and increased their awareness of acceptable quality.

Since judgment is often involved in the inspection process, our inspection supervisors will now be reinspecting regularly a sample of their inspectors' output. Hardware audits mentioned before will provide a regular added insight to our inspection effectiveness. Hardware is now starting to move through added mandatory Government inspection checkpoints, and that will allow us to keep our inspection criteria correlated.

Long-term quality improvements will result from giving each performer, at each level in each function, the opportunity and the requirement to be responsible for the quality of his or her own

output. Each employee has stop authority if he or she sees something thought to be wrong or is uncertain of his or her own work.

In our restart process, the stop button has been pushed several times—to our benefit. We have adopted the "fix the problem, not the blame" concept that focuses on causes of problems rather than punishment of a participant.

A key audit, manufacturing floor disciplines, is first of all a self-audit. Corrective action responsibility and authority for defect reduction now rests squarely with the performing line organizations. We are aiming for personal responsibility even within a large and complex organization.

Suppliers play a very large role with and for Hughes. As part of Tucson operations, we work with 150 key suppliers and over 4,000 nationwide. We are adding a requirement document flow down control similar to our in-house work instruction control. We have sponsored and will provide more focus to supplier conferences for effective feedback from our suppliers.

We are receiving encouraging feedback from our suppliers, indicating a solid recognition and commitment to a sustained emphasis on quality. We will pass along our own defect reduction process experience to selected key suppliers and will expect them to participate in a similar fashion.

Our upgraded receiving test capabilities will supplement an improved corporate-wide supplier rating system. We are minimizing reliance on source inspection at our suppliers' plants by beefed-up in-house test and physical analysis laboratory capability.

Our plan for restarting the hardware frozen in place when we suspended assembly operations has three tracks. The first is formally to reinspect and rework as appropriate. The second is to perform each subsequent, restarted assembly operation to upgraded processes. The third track is to assemble to new processes.

Track one is now underway in almost all areas. Track two is starting in a few areas. We expect to have completed the first, all new, track two circuit card assemblies by the first of November. Track three will start in our new circuit card assembly area, and continue forever, as new processes are added throughout the plant.

It is certainly proper to recognize Government and industry organizations who have freely and openly given us support and assistance. They are:

Bendix Oceanics Division of the Allied Corp.; Underseas Systems Division of Honeywell; the Equipment Group of Texas Instruments; Northrop Aircraft Division of Northrop Corp.; the Air Force Systems Command and its Contract Management Division; Army Material Command and its Missile Command; Headquarters, Naval Material Command; and Naval Air Systems Command; as well as the resident Air Force plant representative at Tucson.

We thank them, and we expect to continue to work with them.

Another important feature of our plan involves coupling our quality upgrade findings into the design engineering activity. One of our new defect reduction process control points specifically analyzes engineering changes with the goal of attacking the cause of errors that may have necessitated changes. We are adding design process monitoring to assure detailed conformance to program requirements.

We recognize the need to track progress as it is being made. We have identified about 800 specific milestones to be met over the first 6 months. Progress reviews are held weekly with our customer agency. As of last weekend, 360 specific milestones, of 400 scheduled through this month, have been accomplished and submitted for customer review.

A number of lessons emerged. We have analyzed our recent experience to find the lessons that might have prevented the problems, or can lead us to even better operations and products in the future. These lessons fall into several categories.

The first is understanding and agreeing on objectives. Our overall objective is to deliver the highest quality hardware at the lowest possible cost, and we believe that also to be the common objective of each of those concerned with defense. However, we have at times focused on individually attractive subgoals at the expense of the overall objective. Let me give you some examples.

Field performance is the ultimate essential. A review of firing records of our missiles shows them to be very, very good. Over 1,500 firings of all Maverick missiles have achieved 85 percent hit record. In actual combat the record is even slightly better. Our infrared-guided Maverick performed equally well during very demanding development and operational testing. This success rate is excellent, considering that IR Maverick is just now entering high-rate production.

Our Phoenix air-to-air missile has been similarly successful. Ninety-two percent of AIM-54A missiles have guided successfully to the target. The newest variant, the AIM-54C, has achieved nearly equal record during a large number of test firings.

Our TOW missile has demonstrated firing reliability of greater than 90 percent in well over 10,000 firings. General Bunyard provided greater detail on that.

These three systems represent nearly all of the missiles delivered from our Tucson facility in the last decade. With successes such as these from thousands of launches, we believed that our missile quality was adequate, even though quality deficiencies caused us to rework and retest too often in producing those missiles.

Another example, production schedules. Manufacturing is traditionally judged by performance to production schedules, which are easily measured. Up to the recent point of simultaneously introducing several new equipment designs into production, our Tucson record was very, very good. These new products have caused us start-up schedule trouble.

In an environment where schedule was king, the behind-schedule position only served to heighten its demands. We lost sight of the overall objective while pushing another classically important one.

A third example, labor efficiency. Over the past year much attention has been given to control of measured labor and its related cost effects. At Tucson, we were proceeding on a productivity plan whose centerpiece was direct labor efficiency. That goal was being closely tracked, and substantial improvement had been made. In seeking near-term labor efficiency, we made the task of "building it right the first time" more difficult. In retrospect, we should have worked on quality first and looked for improved labor efficiency as a resultant of that effort, rather than as an end in itself.

One more example. With the best of intentions, we sometimes tie ourselves in knots. As regulations and specifications cascade downward, they tend to become rigid through interpretation and practice. Then, when threatened by criticism, practitioners can retreat into the safety of this maze. That places an elusive, but very real, burden on our whole system. Without really being aware of it, we can drift toward substituting an objective on nonfailure for one of accomplishment.

We are sharing our top objective with our people and suppliers, inviting them to help us reach that objective. Reasonable interpretation of the means will help us reach the desired ends.

A second major lesson is putting quality first. Our corporate direction now requires this. We have seen enough in our company and in others to be convinced that when broad quality comes first, schedule performance and lower costs will follow, not immediately, but eventually. Total quality strings together a series of people, each doing his or her job so as to satisfy his or her customer, who is the next person in line, then in joining a number of strings into larger ones, and so forth.

The third basic lesson to emerge is the need to create a positive environment for improvement. The environment must welcome and not punish the disclosure and analysis of problems, with the objective of resolving them. Contrary action in our overall system are counterproductive to improved quality and lower costs.

Fix-the-problem, not the blame is an axiom of total quality that requires a major cultural change. We almost unconsciously pounce on the organization that discloses its own problems. We invite defensive responses and risk driving them back underground.

Our common objective is not to punish; our objective is to improve.

A conscious, cooperative team effort to reach the common goal of the highest quality hardware for the lowest cost, by insisting upon a risk-free environment for improvement, can work wonders. We were taught, or retaught, that lesson by our own people over the last 2 months.

We turned to all of our employees and received a fantastic response. Their ideas have been very, very helpful. They feel good about the new priority given to quality. They now own part of our challenge. We mean to protect that trust. I am very proud of our people. They are anxious to get rolling again and to show how well we can do.

The pain of our current situation is clearly shared by our customers and by Hughes. Likewise, the future benefits will be shared. Improved quality, lowered cost and improved readiness for the Government; lowered cost, restored confidence, and an improved competitive posture for Hughes.

This concludes my statement, I thank you for your patience for letting me give it all to you. I will be happy to expand on any portion or respond to any questions.

Senator QUAYLE. Thank you, Mr. Shull.

Let me begin where Mr. Shull left off, and that is that quality should come first. I am a little bit surprised at General Weiss' statement that in this case quality did not come first. Quality assurance clearly was not the top priority at Hughes.

I sincerely believe that when you are looking at putting weapons in the field and trying to make them work, we can't sacrifice quality. Perhaps some good is going to come out of this situation in that quality assurance will receive higher priority. I see everyone nodding yes. It is very unfortunate that a situation like this had to take place before we have some consensus on the issue.

I think we also have made some inroads in that we have learned the benefit of breaking down these systems to see what they really look like, rather than simply relying on the test results. If we break systems down, we can look at the quality of workmanship.

Having said that, as I said at the beginning, there are two problems that we are focusing on. One is what are we going to do in the short-term, or what is going to be the remedy to this situation? Second, how will we reorganize our procedures; to improve quality assurance?

Let's take the first consideration. We now have an example where we have seen a lack of quality workmanship. These were not cosmetic problems, but were very significant problems in the quality assurance programs. DOD has taken the unprecedented action of stopping progress payments; and we now find ourselves somewhat in limbo.

I believe, General Bunyard, you gave probably the most detailed response regarding the Government-contractor working relationship and what we expect out of the contractor.

I would like to ask General Weiss and Commodore Finneran, what is the recommended remedy in this case? I preface that by saying, that if we really are going to be serious about quality assurance, we must put teeth in our quality assurance programs. I certainly understand and sympathize with Mr. Shull on this point, that we are not here to simply punish, but to try to sort out our problems and to move forward. I must note, however, that we are going to have to see a very appropriate remedy in this case, one that is going to send a message to future parties, both Government and the contractors, that we are serious about this. These are serious defects that have come up, and in the future there are going to have to be very serious, substantive, and perhaps painful remedies.

Let me ask you, General Weiss, what do you expect out of Hughes in relation to the Maverick? What do you think they should do? Do you think that they should come in and "fix" the problem and, if so, at what cost?

General WEISS. Those negotiations are currently underway, but I am really not prepared to discuss the extent of the negotiations. They have been underway for several weeks, and I think the parties have been working honestly and sincerely to resolve that.

The premise of the Air Force, the Army, and the Navy is that the contractor shall pay all of the costs that are related to fixing the problems in the near-term. In addition, for work in process, or things that are fielded, the contractor should have liability to cover the fixes of those kinds of problems that may crop up as a result of the defects that have been noticed in the plant in the past 4 or 5 months.

Senator QUAYLE. Basically, you are saying that the contractor should fix all the defects, fix all the identifiable problems that we have, at their cost.

General WEISS. Yes, and how you implement that and how you sort through that is part of the negotiations that are underway at this time.

Senator QUAYLE. As far as who is going to pay and who is responsible, there is not too much of a problem there, is there? Is there any other option?

General WEISS. No, we don't believe that there is another option, but it is a very difficult and complex thing to do. You have to categorize costs, which costs should be reimbursed or paid for by the contractor. You have to look at periods of time for liability. You have to discuss the schedule adjustments that have been caused by the delays that we have experienced. Then you have to look at kind of an umbrella arrangement as to closing out these issues.

So it is not a single thing such as saying, you will pay all the costs. It is a question of defining those costs and making sure that the taxpayers are adequately protected.

Senator QUAYLE. Which costs would you think that the Air Force would be willing to absorb themselves?

General WEISS. I really can't tell you, Senator. I am not involved at this point. I think that I would be speaking out of turn in speaking uninformed. It is a matter between the Air Force contracting officer, representatives of the other services, as well as the contractor.

Senator QUAYLE. What is the Navy opinion on this as far as the remedy that should be applied? What are you asking for?

Commodore FINNERAN. The Navy's position is that all AIM-54C missiles which have been delivered, will be inspected and returned to the contractor, as necessary, to fix or repair any quality deficiency that is found. Our position would also be that total costs of that repair or that remedy will be borne by the contractor.

Senator QUAYLE. General Weiss, is there any disagreement, or are you following the same basic principle?

General WEISS. Yes, the principle is exactly as stated.

Senator QUAYLE. Mr. Shull, is this going to be acceptable to Hughes?

Mr. SHULL. I, too, like General Weiss, have not been a party to those negotiations. There are a number of people who are detailing them with final agreements to be made at a level higher than mine in Hughes Aircraft. To understand the complexity of that detailing, we may take months to negotiate an original contract, and it may be an inch thick. So in order to get the points pinned down, it takes some detailing work.

I can tell you this, it is the Hughes position that we will meet all of our contractual obligations and more. The problem is in defining "this." When someone says, will this all be paid for, the "this" has a lot of breadth, and some limits have to be defined and understood, and that is what we are engaged in in the negotiations.

So conceptually, we are saying, those things for which there is an obligation on the part of Hughes, we absolutely will do, and we are going to go a little bit further than that.

Senator QUAYLE. Let's get a little beyond the concepts here and see if we can sort through the vaguaries of contract law and theories of legal responsibilities and liabilities. I think we are really down to the issue of who is responsible for deficient. The Navy, and

the Air Force in particular, on the Maverick and the Phoenix missile systems have said that upon inspection, they intend to return these systems to Hughes, and that they want Hughes to repair them. They want the costs to be absorbed by the contractor. My question is, what is wrong with that?

This is the crux of the issue. I cannot imagine how we get ourselves into such a position, and I don't know what the final resolution of this problem will be, but I can tell you that this committee is going to have a keen interest in the final resolution. We in the Congress are absolutely bound to protect taxpayer interests, and also the interests and lives of our military men and women in the field. I can't see how you as a contractor are not going to take those missiles that have clear, identified faults and accept and repair them at your expense. I don't see how or why you should want to get around that very basic premise.

Mr. SHULL. I don't want to hide behind legal interpretations because I don't even know what they are. But from a practical standpoint, if our missiles in the field are faulty, we will fix them, that is for sure. The difficulties and the details of determining, what is appropriate is that there are technical decisions to be made.

You see, our record and the record of the products in the field have been good. To fix for the sake of fixing may not be mutually productive. We are not going to renege on any obligations to fix products in the field that have been found deficient because of workmanship. Absolutely, we will do that.

Senator QUAYLE. I think, if I hear the Commodore speaking correctly, that the negotiations are currently underway and that we agree there are some deficiencies, some defects. The services expect to return those to Hughes and have you fix them at your cost. I think that is the position of the Navy, and General Weiss says that it is the position of the Air Force.

I heard something earlier about an extension of warranties, or something like that. I don't think that is a very viable option. I think what we are talking about is getting these things repaired, or getting them fixed, and that means returning them to the contractor and have the contractor repair and absorb the costs.

Mr. SHULL. We clearly expect our products to work correctly in the field. If there is evidence that they are deficient in the field, to what we were supposed to deliver, we will fix them.

Senator QUAYLE. Isn't there a problem here not only in the testing but in reliability? They may work under certain test procedures, but they also clearly do not meet contract specs. I hope I am not sensing a reluctance here, Mr. Shull. Maybe you are not the person to be asking, but you can take this back to those people who are in a position to evaluate it. I certainly hope that there isn't a prevailing attitude that "well, we had pretty good test results, therefore, we feel there is not that much of a problem." I hope there is no feeling that these things are more cosmetic than they are substantive.

I don't think that there is any dispute, that these defects are substantive defects. The quality of workmanship has been very, very poor in several specifically identified cases. You may have had successful tests, but there clearly are workmanship deficiencies. We

can see if circuits are soldered correctly or not. It doesn't take a whole lot of engineering expertise to identify defects of this sort.

What I am sensing here is that there may be a reluctance to accept these missiles and repair them, whether they be for the Navy, the Air Force or the Army. This problem is here and it is real. We see it, we want you to fix it, and you are going to pay for it. That is where we in the Congress are coming from on this matter.

The question gets down to one of reliability, and that is where my interests lie. I think as one looks objectively at this thing, it is not our intent to simply punish. There is a fundamental principle that there have got to be certain quality standards that we must adopt here, and I think that we have been far short on the "standards" in this case. I think everybody agrees with that.

You will take some 800 steps, according to your testimony, to improve that. I congratulate you for it. I congratulate you for the position that you are now taking that quality must be first. It is too bad that we didn't have that commitment from you before, but that is water over the dam. What water isn't over the dam is how we ultimately resolve the problem.

We have a problem out there, and we must know how it will be addressed and where the cost is going to be assessed. I assure you that I think it would be a very, very big mistake to believe Congress and the taxpayers will approve any kind of a settlement where we are going to nod or wink, and say: "Well, yes, this is a problem, and we won't do it next time." We are not talking about that. We are talking about a very, very serious matter here. I can't express it in any more direct terms. Substantive steps must be taken.

This is our short-term situation, but as I said earlier there is a long-term situation that we want to get into later on. The short-term problem is one that has to be dealt with soon, and I can tell you that this committee, myself and others, are going to be looking very, very carefully at the remedies prescribed by Hughes and the services.

My time has expired. I have other questions, but at this time, I will yield to Senator Levin.

Senator LEVIN. Thank you, Mr. Chairman. Let me pick up on that point. There are many other points that we will get to, but let me just pursue that issue with you.

I asked General Thompson of the Army the following questions. He said that we had a stockpile reliability program. I will quote him:

> We have been testing the missiles all the time, and they have been 94 percent. We have torn down some missiles, and there were workmanship problems that were not critical to performance of the missile, but should be corrected because they are not acceptable.
>
> Senator LEVIN. Why do you want them corrected?
>
> General THOMPSON. Because we don't know what it does after the missile has been in the field for some time.
>
> Senator LEVIN. So you are concerned about performance?
>
> General THOMPSON. Yes.
>
> Senator LEVIN. Based on the workmanship, you say?
>
> General THOMPSON. Yes, sir.

General Bunyard, would you agree with General Thompson's answer? I know he is a four star.

Senator QUAYLE. He agrees.

General BUNYARD. Absolutely. I was not here at that particular hearing, but I am sure that he is referring to the capstan problem that I referred to in my discussion of the 7,500 missiles that we currently have in storage at the plant, plus 10,000 that are over in Europe. As I indicated, it is not a problem for performance at the present time because we have gone through and have done our flight testing, and we have not seen anything that caused us to be concerned.

The point General Thompson is making, which I reiterated, was that Hughes has agreed to fix those capstan problems at no cost to the Government. As we go through our additional testing of teardown and flight of missiles that are in Europe, and that is the additional program that we talked about that General Thompson referred to in his testimony, if we see the same thing that we have over in the European environment, Hughes has agreed to go over to Europe to our depot, Meinz Army Depot, and make the necessary corrections.

Senator LEVIN. I am not sure at all that General Thompson is referring to the capstan problem because he said that there were workmanship problems that were not critical to performance of the missile but should be corrected because they are not acceptable. Would you agree with that, that the workmanship problems should be corrected?

General BUNYARD. The workmanship problems that we found in the teardown of the missile, the answer to that is, yes, those should be corrected, and Hughes is correcting them.

Senator LEVIN. How many workmanship problems did you find in the teardown of the missile?

General BUNYARD. As I recall, sir, we had a total of 18 workmanship problems.

Senator LEVIN. How many of those 18 should be corrected?

General BUNYARD. I would have to go back and refer to each one of them, and I will be glad to provide that for the record.

Senator LEVIN. Are you saying that some of the 18 workmanship problems need not be corrected?

General BUNYARD. That is correct, they would have no impact whatsoever on the performance.

Senator LEVIN. Why did we require it to be done in the first place?

General BUNYARD. As the contract is laid out, the specifications, the procedures, and the processes with which the production is going to go through, and the inspection stations that they should be going through, everything should be done according to those specifications.

Senator LEVIN. Why doesn't it affect performance?

General BUNYARD. There are certain things that would affect performance, and then there are others. I cited, for example, in my testimony, scratches on metal surfaces. The scratches are not supposed to be there according to the design specifications, but that would have no impact whatsoever on performance.

Senator LEVIN. Then why do we care if they are there?

General BUNYARD. What we try to get, sir, in our production line is a top quality missile.

Senator LEVIN. Why do we care if there are scratches there if it doesn't affect performance?

General BUNYARD. One indication would be that the personnel that are on that production line are not paying the attention that they should be paying to the putting of that missile together. It is an indicator, therefore, we want to be very specific as to how that system should be put together, and to do that, we have certain things that are laid out at each assembly point and each inspection point.

Senator LEVIN. You don't know offhand how many of the 18 workmanship problems that were discovered in the teardown need to be repaired because they might at some future date affect the performance? You can't give us that number now, you will give it to us for the record.

General BUNYARD. That is correct.

Senator LEVIN. Do you know if it is 10 of the 18, 16 of the 18? Do you have any estimate?

General BUNYARD. I will have to look at that.

[The information follows:]

The 18 workmanship problems were reviewed. None of these will degrade the field inventory.

Senator LEVIN. Is it the Army's position that any defect in workmanship that might in the future affect performance must be repaired at Hughes' cost?

General BUNYARD. Absolutely.

Senator LEVIN. Does Hughes agree with that that any defect in workmanship which might in the future affect performance will be repaired at Hughes' cost?

Mr. SHULL. Any defect in workmanship as described by the specifications governing workmanship, yes, sir.

Senator LEVIN. What about defects that might affect performance, period?

Mr. SHULL. As to all defects affecting performance, I could not say yes, because we don't know whether they derive from us or from general system requirements. Specifically, I would have to say no, not necessarily to all defects.

Senator LEVIN. You are doing something in the field, and you are tearing them down. Is that the 10,000 missiles that were referred to?

General BUNYARD. That would be part of the missiles, those 10,000 missiles.

Senator LEVIN. Why are you tearing down some of those 10,000 missiles?

General BUNYARD. Because we want to go in and reassure ourselves that we do not have any problems out there that might crop up in later years. As I indicated earlier, when we first started deploying the TOW missile system to the field, we had a 5-year service life. Through our inspections, and through our firings, we have been able to extend that to 16 years. We want to ensure that we have just as reliable a missile at 16 years as we do at year one, and that is why we do that particular teardown.

Senator LEVIN. Do you have any reason to believe that the defects in workmanship might affect their performance?

General BUNYARD. No, sir.

Senator LEVIN. But you don't know until you have looked.

General BUNYARD. We feel comfortable at this point in time that the missiles that are in the field today are reliable missiles and will carry us to that 16 years of shelf life.

Senator LEVIN. You are looking just to make sure.

General BUNYARD. Absolutely.

Senator LEVIN. Is one of the reasons that you are looking back at those because of what you have seen in that recent tear down?

General BUNYARD. Yes, sir.

Senator LEVIN. That worries you a little bit?

General BUNYARD. Yes, sir.

Senator LEVIN. What was the reference made to the 10,000 missiles in this memo that I am going to read to you that was signed by Colonel Hagan, who I guess is here this morning, to the chief of the Air Force quality assurance at Tucson. It is dated July 17 of this year on form 47. "As a result of the above inspection method, approximately 10,000 TOW missiles, containing nonconforming hardware, will be delivered to the Government."

General BUNYARD. Sir, that was the one that I addressed in my testimony that had to do with the terminal that was located on a circuit board and that had to do with the skip lot sampling.

The nonconformance that was written up by Colonel Hagan at that point in time, and rightfully so, was that the contractor did not conform to the specifications, that is, the procedures that he should have followed, that being that when he went through three lots and there were no deficiencies, then he could skip to every 10 lots or every 6 months. However, the requirement also exists that he must come in and provide a certification on each lot that it has been built to the technical data specifications. He did not, and that is why Colonel Hagan wrote this up.

Subsequent to this one dated July 17, in September 1984, after they had gone through their analysis, they found that the material was OK, and the missiles that had in fact been built under this particular approach were OK. He came back and indicated that the corrective action plan had been received and approved. He followed this up with another form 47 in September.

Senator LEVIN. Let me just go back to this one. This form doesn't say that there was an absence of certification, or skipping of inspection. This form says that approximately 10,000 TOW missiles containing nonconforming hardware have been delivered to the Government.

General BUNYARD. That is correct, and that is what he is referring to, it is the type of plating that was put on that terminal.

Senator LEVIN. That did not conform?

General BUNYARD. That did not conform to the specs, but what we have found in this particular analysis is that either type of plating, whether it be tin/lead or tin, was meeting the actual performance. So an engineering change proposal, that is the way we change things on the production line, has been submitted and accepted and that will clear up the paperwork.

Senator LEVIN. In other words, the wrong hardware was there, but the hardware which was there has now been determined to be acceptable to the Army.

General BUNYARD. That is correct.

Senator LEVIN. I have a different line of questioning that I want to pursue, and my time is up.

Senator QUAYLE. Lets take a look at the larger problem here. The thing that bothers me is that we had these problems, and they were not really identified until a missile was opened up. We have heard some discussion and explanation as to why this occurred when it did.

Let me start with General Weiss. It seems to me that the system that we had in place, the checks, the quality control personnel that were there on the scene simply didn't work. It just nearly didn't work. These defects should have been picked up, and they weren't.

What went wrong? I have a hard time believing that it is the way our people are told to do things. Do you have a shortage of quality people out there? What went wrong? Something got off track, and it wasn't identified until they broke down that missile. Where did our procedures really fail in this, in your opinion?

General WEISS. Senator, I think we recognized that there were problems there by these 80 deficiency notices that were provided monthly to the contractor, both in hardware and procedures. A lot of it was in the fact that the procedures were not followed.

I think what went wrong, and the fact that it wasn't picked up maybe as early as we would have all liked it to be picked up, recognizing the fact that we had some problems communicating to the contractor and getting his corrective action as timely as possible, was the fact that we probably underestimated the scope of what we were seeing.

You must remember that in these last 12 months, we were working on the end of full scale development of IR Mavericks, and also developmental and early production units of the Phoenix. While we were recording and reporting and working with the contractor to get his attention, we didn't believe the scope was as broad as it turned out to be. We should have surfaced it to top management and taken more positive, pecuniary kinds of actions.

This was further complicated in the beginning of the year when the contractor started to reorganize. He announced a reorganization in Tucson, and then went on to a reorganization in Canoga Park. We felt that these kinds of reorganizations would help ameliorate and correct the problems; that didn't materialize. We found that the announcements of the reorganizations, in our view, tended to confuse the issue more and put off the final resolution.

If I had to say what it was, I believe it was the fact that we were in very early, low rate production. You normally have more problems at that point than you do when you get into a mature production line. I think that we underestimated the scope of the work. The contractor's reorganization, I think, contributed to the problems in that we weren't able to get some of the answers and some of the corrective actions.

Probably the last cause would be the fact that we are always making a trade off in what we do in a plant, and that is to trade off looking at procedures and policy, and how they flow down to

the floor factory surveillance, either through random selection of product or through a mandatory inspection.

We, over these past 12 months, have been working from a base of people—we didn't have the number of people that we needed. I don't want to use that as an excuse per se, but we were spending about 10 percent of our available hours in the quality work force looking at product, and the balance of the time was looking at procedures because we recognized that if we can correct the procedures that the flow would come down and fix the product.

Trying to fix the product was a Band-Aid on a symptom. The symptom was the lack of procedures. Our objective is normally to spend approximately 20 to 25 percent of our available quality assurance people inspecting product based on our current manning standards.

When you take these four factors together, I think that allowed the situation to continue and not be surfaced as early as it possibly could.

Let me say one other thing. Teardown is not separate and aside from our quality assurance program. It is an integral part of it. When you start seeing a lack of systems being followed. When you start seeing workmanship problems on the factory floor. When you start seeing the results of a training program not giving you what you want. The next aspect of your quality assurance program, and rightly so, was for the Army to come in and tear down a weapon system, for the Navy to come in and tear down theirs.

In some of these cases, it was a twofold thing. It was to get ready for a DSARC or a major production upgrade. We, in the Air Force, were ready to tear down and had planned to tear down an IR Maverick in August. We were going to do that, getting ready for our actions to go into negotiation on a higher rate production. What we did, when we saw what was happening with our colleagues, was move our teardown from August to July.

Believe me, MIL–Q–9858A is a good system. Like anything else, it can always be fine tuned. I feel that we are looking at that now under the direction of OSD. The people, you can always do better with more, and you can always do better when your people have higher grades, and when you have a larger volume to pick from.

I really believe that we are doing things in training within the Air Force and the other services to enhance that. We are constantly working with OMB. I can show you what the standards are to be a GS–5, –7, and –9, it is a tough problem. I don't believe that this is something that we weren't aware of. We are not surprised about it. If anything, we are just surprised about the scope of it this early in our production build up in the missiles involved.

Senator QUAYLE. You said that the teardown was going to take place in August anyway, no matter what?

General WEISS. Yes, on the IR Maverick.

Senator QUAYLE. This is standard operating procedure—to tear down a system? Would this be done by just the Afpro? Would each service do it automatically as part of their quality program?

Commodore FINNERAN. we don't automatically in the Navy do a teardown, but sometimes for good and justifiable purposes, sometimes just to make darn sure, as was the case here, when certain

events are to happen like increasing production rate, we will do a teardown.

Senator QUAYLE. Besides the increase in production rate, you must have some indication that there were some problems with what was going on at Hughes, did you not?

Commodore FINNERAN. We did.

Senator QUAYLE. You did? There was some feeling out there that things really weren't going the way that they should, is that not correct?

Commodore FINNERAN. That is correct. There was some feeling, and I think there was ample evidence given here with the documentation that had been presented to Hughes regarding some of the nonconformances in their quality, that gave us some information or insight into the quality of workmanship. But the main reason that the teardown was done on the AIM–54C, though, was to have information well in hand to go forward with the DSARC, to make sure that we could justify a higher rate of production.

Senator QUAYLE. It is a bit unusual, though, for the other service to go ahead and tear it down sooner, is it not?

Commodore FINNERAN. I think General Weiss was referring to the teardown of a Maverick.

Senator QUAYLE. He was referring to the teardown of a Maverick. But if you would find problems with a Maverick, then wouldn't you find that there had been a systemic problem, and would you not also have found it in the Phoenix as well as the TOW?

If it comes down to workmanship problems on the plant floor, and if you have workmanship problems on the Maverick, are you not probably going to have workmanship problems on the Phoenix also?

Commodore FINNERAN. I would expect that.

Senator QUAYLE. This is what really bothers me about the process that we had in place here. The people that were closest to the program, and who had the responsibility for quality assurance, seemed not to have the feeling that something was genuinely wrong. That indicates something is fatally flawed in the way that we do quality assurance. It is a troubling thought.

As you look to reform the system, that has to be a vital consideration.

General WEISS. The people involved were seeing it happening. You can't issue 80 of these things a month and not be sensitive to the fact that you have a problem. During this period of time, we issued 16 forms 47, which is the document that Senator Levin read from, to the chief operating officer of Hughes Tucson. So it was being surfaced to management as well.

What was happening, again, I think, the people were sensitive to what was going on in the facility, the fact that there were growing pains, that there were large numbers of people being employed, increased from 4,000 to 6,000 in a short period of time.

We also had a management problem. We reassigned two people in our quality shop, not because we feel they did anything wrong, but one was a man who is getting ready to retire, who was ill and not there, and the other who we felt wasn't sensitive enough to what was going on. These are normal problems when you are dealing with a lot of people and a large staff.

Senator QUAYLE. Senator Levin?

Senator LEVIN. Does the program manager get the form 47?

General WEISS. No, sir. The program manager doesn't get the form 47, but in a monthly report to the program manager, he gets a summary, a narrative of what was done in the area of quality, which would highlight the form 47.

Senator LEVIN. So the program manager would know on a regular basis all of the workmanship problems with these missiles?

General WEISS. Yes, sir.

Senator LEVIN. When did you decide to tear down that Maverick missile? You said that you were going to do it in August. When did you make the decision to do that?

General WEISS. In July sometime, right after we saw what was happening with the Phoenix.

Senator LEVIN. That is exactly the point. It took the Navy tearing down the Phoenix, because they were having a production increase and just wanted to do it. They did it, and it was that teardown which precipitated you to decide on the Maverick teardown in August. That is what it really comes down to.

General WEISS. It was scheduled. We elected to move it up because of what we were all seeing.

Senator LEVIN. Now you are saying that it was scheduled before the Navy tore it down?

General WEISS. It was always scheduled in August, sir.

Senator LEVIN. When did you first schedule it for August?

General WEISS. It had been scheduled for August for a long period of time. These things are placed into the program as you structure the program.

Senator LEVIN. Because of the milestones?

General WEISS. Because of milestones, and points in time.

Senator LEVIN. Not because of all of the problems in quality?

General WEISS. It was moved up. It was scheduled in August, and it was moved up to July because of the experience of the Navy.

Senator LEVIN. So that we are very clear, I think this gets to a critical point here, there was a milestone coming up in August and a teardown was scheduled, not because of any of the quality problems discovered in the prior couple of years, but because a milestone was going to be up. Is that right?

General WEISS. Yes.

Senator LEVIN. Then after the Navy tore down their Phoenix in June, you saw problems there and accelerated the teardown of your Maverick. Is that right?

General WEISS. Yes.

Senator LEVIN. That kind of goes to the heart of the problem it seems to me. You have a quality assurance program that did not lead to what should have been done, and that was to tear down one of these things.

We had years of paperwork going back here. You indicated in your testimony that from 1983 to 1984, you had 80 deficiency reports, each month, 40 of which required the contractor's written response of corrective action. Then you say that you had audits that identified quality problems between May 1982 and October 1983 on the TOW.

Then you indicated that there were manufacturing and quality problems revealed by the Contract Management Division's review in October 1982. A followup review in May 1983 found little progress in correcting the earlier deficiencies.

Finally, the Navy, for whatever reason, it just happened to be a speedup in their own production or an increase in their own production, tore down one of their missiles. We found that there were some defects. I want to go back to those defects just for 1 minute.

General Bunyard, I asked you how many problems were disclosed by your teardown, and your answer was 18. Let me rephrase my question because I didn't phrase it quite technically or accurately enough. How many problems did your teardown disclose?

General BUNYARD. Would you say that again, sir, how many problems?

Senator LEVIN. How many findings did your teardown of the TOW missile turn up?

General BUNYARD. The findings that we had at that point in time were 79 findings.

Senator LEVIN. Would you say that findings is a synonym for problems of some kind?

General BUNYARD. Yes, they were not in conformance with the specifications.

Senator LEVIN. You found 79 nonconformities as a result of your teardown, and as I understand it 18 of those you would call workmanship defects.

General BUNYARD. That is correct.

Senator LEVIN. There were 79 nonconformities.

General BUNYARD. Yes.

Senator LEVIN. The 18 that you referred to were the workmanship defects, and for the record you are going to tell us how many of those must be corrected, in your view, to avoid any possibility of future performance problems.

General BUNYARD. Yes, sir.

[Additional information follows:]

Corrective action has been taken to resolve all workmanship deficiencies found. No workmanship problems have been found which will result in the degradation of the missile inventory.

Senator LEVIN. So long as we know where we are.

The hardware issue, let's go back to those 10,000 missiles that had the wrong hardware on them. You are now satisfied that even though it wasn't the specified hardware that that will do?

General BUNYARD. Sir, that is a plating.

Senator LEVIN. It is a plating, I don't know the exact words. You have plating on 10,000 missiles which you are now satisfied that while it didn't meet specifications, it is nonetheless adequate.

General BUNYARD. Yes, sir.

Senator LEVIN. Is it as good as the specified hardware?

General BUNYARD. Yes, sir. It meets the specification.

Senator LEVIN. Are they going to continue to use that hardware?

General BUNYARD. Yes, sir.

Senator LEVIN. So you are accepting the different hardware in the future as well as on the 10,000 missiles.

General BUNYARD. Yes, sir.

Senator LEVIN. How is it possible, if that hardware did not meet specifications, that it got through our quality assurance program? That is a lot of missiles, 10,000 missiles, and as I understand that is 10,000 of the TOW-2's, is that correct?

General BUNYARD. Yes, sir.

Senator LEVIN. So that means that it is 10,000 of the 13,000 TOW-2's.

Mr. WILLIAMS. There are 4,000 TOW-2's that have not been delivered yet that would be in addition.

Senator LEVIN. I see, so it would be all the TOW-2's.

Mr. WILLIAMS. No, it is 6,000.

Senator LEVIN. How many TOW-2's have been delivered altogether, General?

General BUNYARD. The TOW-2's to the Army, 13,800, the Marine Corps, 2,600, and to foreign military sales, 32.

Senator LEVIN. To the Army and the Marines, it is about 16,000 altogether?

General BUNYARD. Yes, sir.

Senator LEVIN. Of those 16,000, how many had the nonconforming hardware?

General BUNYARD. I will have to provide that for the record.

Senator LEVIN. We know at least 10,000 from that memo, right?

General BUNYARD. Yes, sir.

Mr. WILLIAMS. At least 4,000 of the 10,000 have not been delivered.

Senator LEVIN. Of the 16,000, would it be fair to say that 6,000 had nonconforming hardware? Is that a fair generality?

General BUNYARD. In the eyes of the inspection at that point in time, that is correct. Subsequent to the point in time, we have found that it is conforming hardware.

Senator LEVIN. Not only is it adequate, but it also conforms.

General BUNYARD. The engineering change proposal that was submitted, that has been accepted, makes that conforming hardware.

Senator LEVIN. I understand that, but before the engineering proposal was submitted and accepted, that was nonconforming hardware.

General BUNYARD. That is correct.

Senator LEVIN. On a good percentage, maybe half of the TOW-2 missiles that we got, until that change was accepted, we had nonconforming hardware.

General BUNYARD. According to the specifications.

Senator LEVIN. I want to know how is it that the quality assurance program could have half of your missiles with nonconforming hardware.

General BUNYARD. I would have to refer that to the inspectors, which is under the Air Force Afpro, to answer that question, sir.

Senator LEVIN. My time is up. If you could submit that for the record, I would appreciate it.

General BUNYARD. We will do.

[The information follows:]

This problem occurred because the quality program procedures were not followed by a subcontractor to Hughes Aircraft Co. This vendor changes plating processes without notifying Hughes. This normally would have been realized immediately,

however, this vendor had an outstanding quality record and Hughes had chosen to utilize the skip sample inspection technique. This type of incoming inspection was allowable by the contract and called for a certification by the subcontractor that requirements were met. Hughes discovered the problem when the subcontractor failed to provide the proper certification. Although the alternate plating method was found acceptable, action has been taken to cease skip lot sampling and increase vendor in-plant surveillance.

Senator QUAYLE. This will have to be the last round, and we will limit it to 5 minutes, I have to leave pretty close to 12:30.

It is my understanding that there is no mandatory training for quality assurance personnel in plant representative offices, and that in most cases such personnel have never attended a formal training course. Is that correct, General Weiss, generally?

General WEISS. Sir, the Air Force, and I think the Army and the Navy have not established mandatory training requirements. We have suggested training requirements for various levels of quality assurance specialists from 5 to 7, and 7 to 9, and on up.

What we elect to do, at least in the Air Force, is to develop an individual development plan as we bring new people on board, and then to update that individual development plan based upon the change in whatever the product line of work is within the company.

I did some checking, and in fiscal year 1982, we had 35 people who attended formal training programs. In 1983, it was 41, and in 1984, it was 46. Some of these training programs, one person may have attended two or three.

Senator QUAYLE. Wouldn't you think that it would be advisable to have mandatory introductory training programs for all of the quality assurance personnel?

General WEISS. We have debated that, and we have discussed it. We have elected in the past, as a result of this quality horizon studies in the Air Force, to go into what we call an intern program, a 2- to 3-year intern program where we bring people in and subject them to formal training. We have brought in so far about 68 people in the last 3 years who are in this intern program.

You could go either way. The problem that we have had, quite honestly, is if you determine that you have mandatory training requirements, and then don't get the training slots or don't get the training funds, that mandatory becomes very meaningless in terms of trying to get the job done. In addition, the Office of Personnel Management won't allow us to say: "You have to have these courses done before you are eligible for promotion to the next grade." So we have shied away from the use of the word "mandatory."

Senator QUAYLE. But don't you think that we should have increased attention to the training of these personnel?

General WEISS. Absolutely, and that is why we established an intern program. Let me say that there is one form of mandatory training. If, in fact, there is a certain specification, such as soldier, that is required on the part of the contractor, and the contractor's employees must have that training, that training is also mandatory for our quality assurance representatives.

Senator QUAYLE. Commodore Finneran, what were the results of the OPEVAL on the Phoenix AIM-54C missile?

Commodore FINNERAN. Generally, the results of the OPEVAL were quite satisfying toward the end. However, in the early part of OPEVAL, we did have some failures. I would refer to Captain Bowes, the program manager, who could give us some details on that.

Senator QUAYLE. Captain, I am aware that there were some missile failures. Is that correct?

Captain BOWES. Yes, sir. In the early portion of the OPEVAL, we had some 10 failures.

Senator QUAYLE. What is the date of this, approximately?

Captain BOWES. We started in the middle of 1972, and we finished up in June 1974. So early in the OPEVAL, as I mentioned before, we did have some failures.

Senator QUAYLE. You are talking about 1972 and 1974—that can't be.

Captain BOWES. I meant 1982 and 1984.

Senator QUAYLE. OK—1982.

Captain BOWES. Yes, sir. We discovered some failures, four of which were failures as a result of incompatibility that were with the aircraft. Those failures were induced by voltage and power transients that the aircraft produced. We found that the easiest way to fix the problem was to make a part of the missile more robust. This correction proved to be very satisfactory.

We found some six other failures during the OPEVAL period. You can look at two types of quality; one is a design quality, and the other is the workmanship quality. We have been talking earlier today about workmanship-induced quality problems. These six problems were design-quality-induced problems, and I will give you a couple of the examples of what we had.

We found two items shorted out, and that the cause of the short was a screw that had backed out. The screws were inserted properly on the production line, however, the engineering drawings did not require any secondary locking mechanism to prohibit the screws from backing out. That certainly is a poor design, and I would say poor quality of the design.

Each one of the failures of the six fell in that category. We found that the design did not adequately accommodate the environment. That is one of the reasons we do testing, certainly. The environment many times is different from what we had expected. We found a transistor lead had broken, and we had a failure because of that. The fix to that was to put a transi-pad, something to alleviate the vibration and make the transistor more resilient to the environment. We fixed this problem and the change has been incorporated in production.

In the latter part of the OPEVAL, as the Commodore described, we put the later production missiles, the 1981 and 1982 missiles, in OPEVAL and we accumulated some 600-plus hours, and we have yet to have a failure on one of those missiles.

Senator QUAYLE. Staff informed me that some of those failures, from looking at them, were unsoldered line filters, and a loose screw. That is a workmanship problem, not design is it not?

Captain BOWES. No. The loose screw is one of those, as I alluded to, I call it a quality in design. The design did not require the lock

tight to be put on the screw after the screw was inserted to prohibit the screw from backing out under vibration.

The solder joint was a blind solder joint. It was a vendor component that Hughes received, in fact, I even have that with me. One cannot visually determine if there is a good solder joint or not. The vendor should have been screening them to make sure that he had good conductivity across each capacitor.

The correction that Hughes put in place, was to do a conductivity check on each of these capacitors is made to make sure that the blind solder joint is, in fact, a soldered connection. This was not necessarily a workmanship problem, but is a poor design.

Senator QUAYLE. They are a combination of both.

Captain BOWES. A combination of the two, sir.

Senator QUAYLE. I think that is fair.

Senator Levin?

Senator LEVIN. Would it be fair to say that the quality assurance failures contributed to the failures?

Commodore FINNERAN. I would say that is true particularly if you look at the most pervasive definition of quality. There is a quality in design element that we think is a significant part of quality. In these cases where we say that there is some design effort that is involved in the end failure, certainly a purist would say that it is an engineering problem because the manufacturer, or the worker, made it precisely in accordance with the drawing.

Senator LEVIN. What about workmanship? Did that contribute as well to those failures?

Commodore FINNERAN. Yes. You would have to say on that solder that it is partially a pure workmanship problem, and it is partially a design problem in that the designer made the board in such a way that there was a blind effort on the part of the worker to make that solder joint.

Senator LEVIN. One of the issues which has been raised in at least one newspaper relative to Hughes was the fact that the former head of AFPRO went to work for Hughes immediately after his retirement. Lt. Col. Grant Heard, apparently, was the head of AFPRO from September 1982 to September 1983. Is that correct? Did that colonel go to work for Hughes?

General WEISS. Yes, sir, that is correct.

Senator LEVIN. As I understand, the head of AFPRO is in charge of monitoring quality at the Hughes production site where 120 defense contracts, roughly, are being implemented. Is that a rough number of defense contracts at that site, or at Hughes?

General WEISS. Approximately, sir.

Senator LEVIN. With 103 personnel under his supervision?

General WEISS. Yes, sir.

Senator LEVIN. I am troubled by the appearance of that.

General WEISS. I am very troubled by it, too.

Senator LEVIN. I think that one of the things this committee has got to look at is the revolving door issue. I am not going to say anything further than I am troubled by the appearance of it. I will leave it at that, but it seems to me that when we have somebody who is the head of the quality assurance at a major manufacturing site, for that person to retire and then go to work for the contrac-

tor creates an appearance which is not desirable and healthy. I will be very careful in saying it exactly that way.

I am not picking on this particular company, by the way either, Mr. Shull. This is an endemic problem as far as I am concerned. We have not solved it yet. We have a statute, an ethic in government statute, which doesn't address this issue. I would hope that this committee would address this issue because it has got to be a problem. It has simply got to be a problem because we have to rely on these weapon systems.

I can't tell you that I am satisfied with the quality assurance program where 6,000 or 10,000, whatever the number is, missiles go through it with nonconforming hardware. I am glad that it turned out that the product is adequate. I have to tell you that I am delighted. We lucked out, but the fact of the matter is that it was nonconforming when it went through. We have a quality assurance program that didn't pick it up.

We didn't tear down a missile until the Navy happened for some unrelated reason to tear down a missile in terms of one of their production milestones, and that makes me very uneasy.

The fact that 90, 92, or 94 percent of your missiles worked, I am glad to hear, but if an auto manufacturer's brakes work 90 or 94 percent of the time, I don't think that any of us would be satisfied. I know you are not satisfied, and that is why you are working, hopefully, to improve on quality.

Quality is what this hearing is all about. I am glad that you have things going where you are going to improve on it. I am glad you acknowledged the deficiencies in it. I think that those acknowledgements this morning have been healthy. We have to do everything we can to encourage you to keep on that course.

We have to improve the system so that we don't by chance find out about problems of the scope that we have had at Hughes. Obviously, we have had problems there that are significant enough to stop payment on a contract and to stop acceptance of a missile, that is a very significant action for the Defense Department. If you have quality problems that big and they are not discovered by our quality assurance system, in fairness looking at this whole thing, they weren't, then we have to look at that system and improve it.

That is not beating up on anybody, that is not doing anything except saying, let's do better for the sake of people who may have to use these weapons, hopefully never, but may have to, whose life may depend on these weapons. For the guy who has the 94 percent, and so forth, out there in the field, if he ever had to use it, the fact that the first 92 worked would not be very reassuring. I think we all agree on that.

I am glad that the chairman did schedule these hearings. I hope that they have been constructive and healthy. They were intended to be so. Let's keep concentrating on that quality issue.

Thank you, Mr. Chairman.

Senator QUAYLE. Thank you, Senator Levin.

I might just reiterate, again, the two problems that we have. The short term one is a resolution of pending problems, and then we have to look at the long-term endemic problems with the quality assurance system. We have come up, perhaps, with some ideas.

I think this is an issue that we are going to continue to monitor, and one in which we will certainly conduct continued oversight. I think the only way we are going to get anywhere is to work together, but as we work together there are going to have to be certain understandings and clear direction on where everybody is coming from. I think I have made my point here today regarding Congress' orientation on this issue.

Senator LEVIN. Could they supply for the record, Mr. Chairman, the outcome of the negotiations as to who is going to pick up what costs, which of the 18, whatever the number the workmanship defects turns out to be, are to be corrected by Hughes, which are not going to be corrected because, presumably, in the opinion of our military, they don't affect performance for whatever reason.

I think that it is important that the record be completed on this issue. We now have a very open-ended question here on three missiles that have defects in them, and we have to have those repaired. I think everybody agrees with that. Those missiles are going to be repaired, but we now have, apparently, to negotiate with the contractor to see which ones are going to be repaired at the contractor's expense. I think the record should be completed by a report by our armed services as to exactly what defects will be repaired and who is going to pay for it.

[The information follows:]

No workmanship problems were found that will degrade the field inventory. Hughes bore the cost to correct all paperwork associated with these missiles.

Senator QUAYLE. As I said at the beginning, we will continue to exercise some very aggressive oversight on this issue. We all have an interest in the ultimate outcome. Certainly, whatever is forthcoming, we in the Congress will take a good, strong second look. I indicated that at the beginning of this hearing and I reiterate it again.

[Questions with answers supplied follow:]

QUESTIONS SUBMITTED BY SENATOR DAN QUAYLE

PLANT REPRESENTATIVE OFFICES

Senator QUAYLE. Do we need larger plant representative offices, and should the qualifications of those serving in such offices be higher?

AIR FORCE

General WEISS. The size of the Air Force Plant Representative Office (AFPRO) is based on the magnitude of government programs at contractor facilities. Government programs have increased significantly over the past years and AFPRO manning has not kept pace with the increase. The Air Force Contract Management Division (AFCMD) identified this increase in work load and requested additional manpower; however, at current Air Force funding levels, additional AFPRO manpower requirements were not funded. The Office of Personnel Management (OPM) qualification standards are the criteria used when filling vacant positions. The level of qualification for a given position is based on job complexity and responsibility. The best qualified person is selected for a position; however, the recruitment and retention of qualified AFPRO employees has been impacted by civilian grade reductions. In some geographical locations, such as Los Angeles, CA, the Air Force finds it difficult to compete with higher paying civilian industry. Because of these recruiting difficulties, Los Angeles AFPROs are currently manned as low as 78% and the yearly turnover rate at one AFPRO exceeds 46%. The potential changes in Civil Service entitlements and retirement programs are an additional factor in the ability of Air Force to recruit and retain qualified personnel.

ARMY

General BUNYARD. The Army only has five plant representative offices (i.e., Detroit Arsenal Tank Plant, Warren, MI; and Lima Army Tank Plant, Lima, OH, under the Tank-Automotive Command (TACOM), and three ARPROs under the Aviation Systems Command (AVSCOM), at Bell Helicopter Textron, Fort Worth, TX; Boeing Vertol Co., Philadelphia, PA; and Hughes Helicopters, Culver City, CA). The size of the Army Plant Representative Offices at these five plants is adequate. The Army also has 14 active Government Owned-Contractor Operated (GOCO) Army Ammunition Load, Assemble and Pack Plants (AAPs) under the Armaments, Munitions and Chemical Command (AMCCOM). The size of the Army quality assurance (QA) staff at the majority of the 14 GOCO AAPs is only minimally adequate. In recent years, the workload has increased at most of these AAP plants which has resulted in additional contractor production lines and shifts. The qualifications of the QA personnel in the five ARPROs and the 14 GOCO AAPs is not a significant problem. However, the GM/GS grade levels of the QA personnel are a problem because of the new Office of Personnel Management (OPM) GS/GM-1910 series, QA Specialist, Classification Standards. The new classification standards do not provide for guides commensurate of the QA management/supervisory jobs. Therefore, it is difficult to retain QA personnel as they attempt to advance into more responsible QA positions. As a result, turnover has been high at the five ARPROs as in-plant QA personnel move to higher grades in other organizations/activities. Turnover is particularly high at the Hughes Helicopters ARPRO, Culver City, CA because of the high cost of living in the geographical area. Here the relatively lower grades of the in-plant QA personnel (GS 1910-9 and GS 1910-11 journeymen) result in frequent transfers to other parts of the country where the cost of living is lower or resignations in order to go to work in more lucrative QA jobs in the private sector. The vacancy rate for QA personnel at the Hughes Helicopters ARPRO is over 15 percent and the turnover rate in fiscal year 1984 was 68.9 percent.

NAVY

Commodore FINNERAN. Staff levels in our Naval plant representative offices are considered adequate. Also, the Navy is engaged in an in-depth survey to gain current knowledge of the expertise and the level of responsibility necessary to perform quality assurance work. The results of this survey are expected to be valuable in defining future position requirements for our quality assurance work force. While undeniably important, the number of capabilities of our people are only a part of the issue. Clearly, we cannot afford to put enough people into a plant to duplicate the contractor's quality efforts. It is the contractor's responsibility to deliver a product conforming to contractual requirements. Our total range of actions in dealing with the contractor must reinforce this message so as to maximize the effectiveness of on-site people.

PERSONNEL MANDATORY TRAINING

Senator QUAYLE. It is my understanding that there is no mandatory training for quality assurance (QA) personnel in plant representative offices, and that in most cases such personnel have never attended a formal training course. Is this correct, and if so, wouldn't it be advisable for DOD to establish a mandatory introductory training program for all new quality assurance personnel?

AIR FORCE

General WEISS. Air Force Systems Command has established a training program tailored to the mission and job essential requirements, instead of a mandatory training course, per se. Mission essential training needs are identified for all QA personnel in the work force. Courses are provided through the AFSC Civilian Quality Assurance Career Management Program to satisfy top priority needs. As a matter of information, during fiscal year 1984, 53 formal courses were conducted averaging 23 students for each course. Although it is possible that some new AFCMD personnel have not yet been exposed to this type of training, most QA personnel have. All new QA personnel receive training based on need. The AFPRO determines the need and provides the training. Formal introductory training is provided to the QA interns who have had very little or no experience.

ARMY

General BUNYARD. This is not correct for Army In-plant Quality Assurance (QA) personnel. Training requirements for Army QA personnel in the five ARPROs and 14 GOCO AAPs are specified in Army Materiel Command (AMC) Pamphlet 702-9, Formal Training Requirements for Army In-plant QA Personnel. Training requirements are identified in the pamphlet as either "core" or "supplemental" and are categorized by type of plant/commodity, i.e., ammunition, aviation, or tank. "Core" courses must be taken by every QA specialist assigned to a plant and include such courses as Defense In-plant QA, Statistical Quality Control, Precision Mechanical Measuring Techniques, Defense Specification Management, Technical Data Package Development/Preparation, Management of Defense Acquisition Contracts, etc. "Supplemental" technical courses are taken when the training course material applies to the specific functions assigned to the individual QA specialist, e.g., QA personnel performing or verifying contractor performance of nondestructive inspection/test (NDI/T) functions would take "Supplemental" technical courses in the applicable NDI/T techniques. Supervisors of the QA specialists are required to use the pamphlet as a guide in developing annual individual development plans (IDPs) for their subordinates and to schedule and track accomplishment of the training outlined in the IDPs. Furthermore, it should be noted that many of the Army's new QA specialists enter their QA careers through the AMC Quality and Reliability Assurance (Q&RA) Intern Training Program. The Q&RA Intern Program consists of 6 months of mandatory formal QA training at the Army Management Engineering Training Activity and 2½ years of structured on-the-job QA training in purchasing offices, technical activities, plant representative offices, depots and/or program management offices. The Q&RA Intern Program began in 1960 and some of our top QA managers are graduates of the program. Therefore, based on the above, we do not believe it would be advisable or necessary for DOD to establish a mandatory introductory training program for all new QA personnel.

NAVY

Commodore FINNERAN. There is no mandatory training for quality assurance personnel. However, training programs have been established and many Naval plant representative quality assurance personnel have participated. Improved training is important, but we believe such a program would be most effective if tailored to specific service needs, product line and work environments. The Navy is currently making a detailed, comprehensive task analysis of quality work force functions. Definitions of tailored training requirements will be one product of the analysis.

DEFECTS FOUND IN MISSILES

AIR FORCE

Senator QUAYLE. Would you please describe the defects found in missiles built at Hughes Tucson Plant? Would you describe these as serious quality problems, and what is the likelihood that such problems would adversely affect missile performance for reliability?

General WEISS. Defects found in the Hughes plant at Tucson can be divided into three major categories: workmanship, engineering to planning translation, and operator compliance to planning.

Workmanship deficiencies included defective soldering, unsoldered wires, and fasteners not torqued to the specified value. Engineering to planning deficiencies included a dimension noted as critical on the drawing not being called out in the work instructions and not on the inspection criteria.

Operator compliance to work instruction deficiencies included use of hardware not in the instructions and components improperly installed.

These problems are serious in that they demonstrate the failure of Hughes to implement an effective quality program as required by contract.

Hughes' ability to test the product to assure functional performance reduces the likelihood of these problems affecting near term performance; however, long term reliability could have been adversely affected had these conditions continued to exist.

ARMY

General BUNYARD. The most serious problem was the out-of-tolerance capstan block located in the missile container. Test date and resultant analysis has shown no adverse effect on weapon system performance. All other noted deficiencies (de-

fects) were classified as minor. The 79 findings on TOW can be categorized as 18 defects in workmanship, 22 in product discipline, 13 manufacturing methods, 11 instruction, 6 design, 6 vendor and 3 miscellaneous findings.

NAVY

Commodore FINNERAN. The types of defects which were discovered in the AIM-54C Phoenix missile manufactured in the Hughes Tucson plant include unsoldered joints, cold and/or fractured solder joints, electrically conductive debris in connectors and on printed wiring boards, kinked or crushed wires, inadequate clearances (i.e., physical contact) between missile structure, components and interconnecting cabling, as well as deficient conformal coating of printed wiring board assemblies. Most of these problems are viewed as being serious by the Navy. An unsoldered or cold or fractured solder joint could fail anytime during the missile's service life. Failure forecasting for the above mentioned types of discrepancies if not exact in terms of predicting exactly when a specific defect will precipitate a failure in a given missile. However, it is intuitively clear that these types of discrepancies will ultimately result in a missile failure if the missile remains in service long enough. Consequently, they are not acceptable.

ROLE OF PROGRAM MANAGER

Senator QUAYLE. What should be the role of the program manager with respect to quality assurance?

AIR FORCE

General WEISS. The program manager (PM) has the inherent responsibility to manage his program. Like other major considerations, the PM includes QA provisions early in the system engineering process to ensure the capability to make measurements, perform tests, and conformity with design criteria and performance requirements are built into the system. Quality assurance provisions are usually tailored to the program as it moves through the phases of system acquisitions, i.e., development through production. The basic requirements for contractor's QA procedures are prescribed in military standards. Additional QA requirements may also be included in the work statement. After the program office executes the contract, it is usually assigned to a contract administration activity (DCAS or AFCMD—AFPRO) to ensure on site compliance with contract QA provisions. The FAR delegates in-plant QA to the Contract Administrative Services (CAS) activity. The CAS communicates in-plant QA discrepancies by Quality Reports to the PM advising him of their impact on his program and status of contractor action. A number of actions are available to the PM to assure contractor's proper quality performance including withholding progress payments.

ARMY

General BUNYARD. The program/project manager is ultimately responsible for the quality and reliability of all supplies delivered under contracts for his weapon system hardware. This includes the responsibility, and related actions, to invoke, implement, monitor, and evaluate all the necessary controls to ensure contract compliance.

NAVY

Commodore FINNERAN. The program manager is responsible for acquiring products in full conformance with all requirements inclusive of quality. These responsibilities extend to management oversight insuring that appropriate quality assurance contractual requirements are established, technical execution is acceptable, and corrective actions are taken when necesssary.

RELIABILITY OF MISSILES

Senator QUAYLE. Based upon the information that has been obtained from the tear down of Phoenix and Maverick missiles, what is your belief about the reliability of such missiles that have been accepted by the Navy or Air Force?

AIR FORCE

General WEISS. All IR Maverick missiles are being reinspected and reworked as required. Adverse operational impact will be reduced significantly due to close sur-

veillance by the contractor and government representatives of the rework and reinspection activities.

ARMY

General BUNYARD. No comment.

NAVY

Commodore FINNERAN. The AIM-54C Phoenix missile has yet to demonstrate in the fleet operational environment, the reliability capability to which it was designed (i.e., 505 hours mean time between failure). However, it is believed that with continued emphasis on manufacturing producibility, workmanship and quality it will meet and even exceed this design threshold. We believe that the design reliability is inherent in the missile. We must simply continue to invoke good manufacturing practices and technology to enjoy the reliability benefits designed into the missile. The AIM-54C missiles which have been accepted, will be returned to the contractor for reinspection and correction of quality deficiencies potentially harmful to reliability.

QUALITY CONTROLS AT OTHER FACILITIES

Senator QUAYLE. Based upon this experience with Hughes, should we be concerned about quality controls at other defense contractor facilities? What assurance do we have that the AFPROs and NAVPROs at those facilities are enforcing relevant quality control specifications to the highest standard?

AIR FORCE

General WEISS. Yes, we have always been concerned and routinely conduct independent review of contractors' operations. It was during one of these reviews that the magnitude of Hughes' quality problems was discovered. We have accelerated our review schedule and all contractors under AFCMD cognizance will have been reviewed by December 1985.

ARMY

General BUNYARD. The Army is always concerned about quality controls at defense contractor facilities. Therefore, the Army Materiel Command has for years implemented a product quality management (PQM) program (to implement Federal Acquisition Regulation (FAR) and DoD FAR Supplement Part 46 purchasing office/technical activity QA functions, formerly Defense Acquisition Regulation Section 14) at its major subordinate command (MSC) purchasing offices/technical activities/program management offices. Under the PQM Program, product quality managers from the AMC MSCs are assigned to a weapons system, components or family of items. The PQM interfaces with the Contract Administration Service (CAS) in-plant QA personnel (ARPRO, NAVPRO, AFPRO, DCASPRO, DCAS residency as the case may be) to verify compliance by the contractor to the contractual technical and quality requirements. Some of the functions performed by the PQM include: establishing the contractual quality requirements, verifying adequacy of the technical data package incorporated in the contract, issuing a QA Letter of Instruction to the CAS in-plant QA representative, conducting a joint QA Post Award Conference with the CAS activity/contractor, witnessing/conducting first article testing/inspection, conducting a joint Quality System Review of contractor/CAS QA operations with the CAS activity during initial production, conducting periodic product-oriented audits at the contractor's plant, investigating/resolving quality deficiency reports from users of Army materiel and assuring effective contractor corrective actions to prevent recurrence, reviewing product quality feedback data from the user, depots, test activities, and CAS QA activity to identify adverse trends and effect necessary management attention to identify and eliminate the cause of problems. The PQM/CAS interface has worked well over the years to assure enforcement of relevant contractual quality requirements and to assure that a quality product is provided to the soldiers in the field.

NAVY

Commodore FINNERAN. We are concerned about quality, and the experience at Hughes has heightened our awareness of quality matters. Further, we believe that our increased awareness and our firmness in accepting only high quality products conforming to requirements have been signaled throughout the defense industry.

Concerning the effectiveness of our NAVPROs, their performance is examined in a variety of reviews. Also, while both plant quality systems and hardware come under NAVPRO quality surveillance, the NAVPRO effort devoted to direct examination of hardware quality has been intensified.

PROBLEM IN TRANSITION

Senator QUAYLE. Are the quality assurance problems at Hughes reflective of difficulties in the management of the transition from the development to production? If so, what lessons can we learn from the Hughes experience?

AIR FORCE

General WEISS. Yes, however, the Maverick was not in rate production but in low rate initial production. During the full-scale development activity, changes in design led to the need for many operations requiring the use of high risk practices that required far more handwork than did the original design. The need for this handwork has been greatly reduced and should be eliminated prior to rate production. Nearly all workmanship discrepancies were a result of this design related handwork. Work instructions that did not reflect the engineering and workers not following the work instructions also contributed to the problems.

Lessons learned included the following:

a. Use mandatory government inspections to evaluate contractors when large numbers of new and inexperienced operators are added to the work force or when significant changes are made to the hardware.

b. Insure sufficient hardware is inspected to identify adverse quality hardware trends.

c. Insure the contractor quality audit system is functioning properly.

d. Insure the contractor quality organization has sufficient independence to accomplish its function.

ARMY

General BUNYARD. From the Army perspective, no. The quality deficiencies noted during the recent TOW audits, surveys, and assessments at HAC, were not a result of transition management.

NAVY

Commodore FINNERAN. The transition from development to production encompassing the maturation of the design and preparation for increase of production rates was a contributing element to the quality problems at Hughes. Among the lessons learned from the problems at Hughes is an increased recognition of the need for early consideration of producibility issues in equipment development. Towards this end, the introduction of the Department of Defense Directive 4245.7 "Transition from Development to Production" is a useful step. Additionally, we have implemented a policy of mandatory contractual requirements reflecting best manufacturing and test screening practices for all electronic equipment, and we are examining widening the use of "tear down" inspections as an effective quality oversight mechanism.

INSUFFICIENT NUMBER OF HIGHLY TRAINED PERSONNEL

Senator QUAYLE. Though we don't want to over generalize from experiences like this one, I am concerned that this episode may indicate that there is an insufficient number of highly trained engineers and technical personnel in the procurement commands. I am concerned that the Federal government may not have the ability to pay the salaries or otherwise attract people who are true technical matches for their industry counterparts. If this is true, the result may be not only poor quality control, but poor cost estimating and generally inadequate surveillance of defense contractors. Is this a concern to you, and if so, should the government consider contracting for more contract support activities so that the services of a greater number of highly trained people will be available to it?

AIR FORCE

General WEISS. The Air Force has a competent, highly trained, and experienced acquisition work force. We expanded our efforts in military recruitment increasing our technically educated acquisition personnel by over 500 in the past four years.

Additionally, we put these people through an intense three weeks of systems acquisition training to further hone their capabilites. On the civilian side, AFSC maintains an overall 97 percent manned rate even though we do have some geographic locations such as Los Angeles and Boston where the cost of living and the competition with private industry keeps us in a constant recruiting mode. In Quality Assurance we started an intern program four years ago which is now graduating highly trained new people at the rate of 25 per year. In addition, we implemented an in-depth training program for our work force which is starting to pay good dividends. We make good use of the Cooperative education program to attract new people as well as other intern programs to grow our own talent. There is no question, our salaries are not competitive with the private sector, especially for highly trained, top people. The gap widens each year and with the constant proposals to cut employee benefits such as retirement, health insurance, and leave we must expend more time and effort on each recruitment. Most of our success is through corporate investment in entry level program. This is cost and time intensive but has been paying off. Solutions to this would include correction of the overall pay disparity, greater use of special salary rates, and local wage rates similar to the Federal wage structure.

The Air Force has long been the leader in contract support. Further, most of that contracting is accomplished in the Air Force procurement command—e.g., almost half of the Air Force Systems Command's total civilian personnel effort is accomplished by contract. Through the MITRE Corporation in Boston and the Aerospace Corporation in Los Angeles we acquire technical expertise to augment that available from within our force. These Federal Contract Research Centers are staffed with highly competent, technical people. More contracting in the procurement commands would be inappropriate.

The government must retain inherently governmental functions. Quality control, cost estimating, and contract surveillance are absolutely governmental responsibilities. Most important, contracting is not the best way to generate more "highly trained technical people"—competitive salaries and congressional funding of these manpower in-house intensive programs is the answer.

ARMY

General BUNYARD. Yes, this is a concern because there are insufficient numbers of highly trained engineers and technical personnel currently employed in procurement commands. In addition, there is little hope of attracting such personnel to the Federal Government to match their industrial counterparts. However, contracting out for such effort is not the answer for it would produce a very unhealthy environment in the work place.

NAVY

Commodore FINNERAN. While it is true that government salaries in and of themselves are not adequate to attract and retain sufficient numbers of high quality technical personnel, other incentives are being stressed to potential employees. These include government funded training (including advanced degrees) and increased responsibility at the entry levels.

An examination of entry level salaries quickly points out the need to continue stressing these incentives when recruiting newly graduated engineers at the entry level (GS–5 and GS–7). The government offers $22,387 for graduates with a 3.0 grade point average (GPA) and $18,070 for others with a lower GPA. Industry on the other hand is paying $6,000 to $8,000 more per year. In 1984, engineering graduates received an average salary of $26,844 per year.

While it is difficult for the government to compete with industry, it is not impossible. We are continually striving to attract top talent by stressing incentives and benefits that the government offers. It is imperative that the special salary rates be retained for critical technical skills and reevaluated with the objective of raising them to be more competitive with industry.

Regarding the use of contract support for technical oversight, the government should not contract for contract surveillance activities for the following reasons:

a. It would compound the stated problem of the government's not being a "true technical match" for industry counterparts. Creating a shadowy third group of private contractors as temporary agents of the government creates no corporate memory or continuity and has potential conflict of interest problems.

b. The stated policy of Office of Management and Budget Circular A–76 is not to contract out "inherently governmental" functions. If it is unclear whether a function is inherently governmental, that doubt alone is a sufficient basis to retain the function in-house.

c. The origin of Federal Acquisition Regulation 42.2 (Defense Acquisition Regulation 20-701) is clear and specific that contract administration in DoD is to be done by a government office. We concur with this position.

OPERATIONAL TESTING

Senator QUAYLE. Has any operational testing been done on the IR Maverick missile? If so, what have the results shown?

General WEISS. An extensive amount of operational testing has been accomplished with the IR Maverick missile, beginning in 1977. In February of that year captive-carry and simulated launch missions using advanced development guidance units on A-7 and A-10 aircraft were conducted at Fort Polk, Louisiana to assess performance in Central European close air support and interdiction scenarios. In January and February 1978, testing was conducted in Germany to evaluate tracker performance in actual European weather conditions. Initial Operational Test and Evaluation was conducted at several locations from February 1981 through August 1982 to address Maverick operational effectiveness and suitability.

The results of these tests proved that IR Maverick is operationally effective. It provides a night attack capability not currently available to the Tactical Air Forces. Operational aircrews of both single-seat and two-place tactical aircraft demonstrated the capability to effectively employ the IR Maverick under varied scenarios and conditions. The capability to effectively launch the weapon in haze and smoke conditions was also demonstrated. An increased stand-off launch range over that of the TV Maverick, which would significantly enhance the survivability of tactical delivery aircraft, was also demonstrated.

Follow-on operational testing is currently in progress to continue to evaluate the operational effectiveness and suitability of production missiles. These tests are scheduled to conclude in May 1985.

DISCIPLINARY ACTION TAKEN

Senator QUAYLE. Has any disciplinary action been taken against any person at the Hughes Tucson plant or at the AFPRO in Tucson as a result of this series of events?

General WEISS. The AFCMD Commander replaced the previous AFPRO Commander in August 1983. The AFPRO Commander position was then upgraded to a colonel position. The present Commander is exercising strong leadership and close surveillance of the contractor's performance. Since the problems in July 1984, AFCMD has assigned a new QA division chief at the AFPRO and replaced the two subordinate branch chiefs.

At the Hughes Missile Systems Group, the Company replaced the manufacturing division manager and restructured the QA organization to make it independent and autonomous from the manufacturing and assembly operations, and named a new QA director.

REVIEW OF AFPROS

Senator QUAYLE. It is my understanding that the Contract Management Division of the Air Force Systems Command has initiated a general review of AFPROs as a result of the episode at Hughes Tucson Plant. What is the purpose of this review? What is the status of the review, and has the review reached any conclusions? (May we have a copy of the final report of this review group?)

General WEISS. The AFSC Commander has established an AFCMD Review Panel to "evaluate the effectiveness of AFCMD contract management in the accomplishment of the overall acquisition mission of AFSC and the other Commands/Services for which AFCMD provides contract management." This panel began work in October 1984 and is to make recommendations to the Commander not later than the end of December 1984. This review is on-going and no conclusions have been reached at this time; however, the results will be provided to you as soon as they are available.

LEGAL AUTHORITY

Senator QUAYLE. What is the legal authority upon which the Air Force relies in terminating all progress payments to Hughes?

General WEISS. Our legal authority for suspending progress payments to Hughes is the clause in the contracts entitled "Progress Payments for Other than Small Business Concerns (1982 Sep)." It is found in the Defense Acquisition Regulation (DAR) at 7-104.35(a). Paragraph (c) of that clause allows the contracting officer to suspend progress payments whenever he finds upon substantial evidence that any of

the circumstances there described exist. The circumstances the contracting officer found to exist were (1) the failure of the contractor to comply with a material requirement of the contract and (2) the failure of the contractor to make such progress that the unliquidated progress payments exceeded the fair value of the work accomplished on the undelivered portion of the contract. The suspension in progress payments was made in accordance with DAR E–524 only after notice to and discussions with Hughes, after full exploration of Hughes' financial condition, existing and available credit arrangements, projected cash requirements, effect of the suspension on Hughes' operations, and the overall equities of the situation. The government exercised its rights under the clause in order to protect the interests of the government, foster satisfactory contract performance, and guard against overpayment and losses.

RELIABILITY OF MISSILES

Senator QUAYLE. Based upon the information that has been obtained from the tear down of Phoenix and Maverick missiles, what is your belief about the reliability of such missiles that have been accepted by the Navy or Air Force?

General WEISS. All IR Maverick missiles are being reinspected and reworked as required. Adverse operational impact will be reduced significantly due to close surveillance by the contractor and government representatives of the rework and reinspection activities.

CORRECTIVE ACTION PLAN

Senator QUAYLE. Mr. Shull, what is the status today of the corrective action plan?

Mr. SHULL. The corrective action plan has been fully approved. Implementation of the plan is well under way.

MISSILE ASSEMBLY OPERATIONS

Senator QUAYLE. When do you anticipate that missile assembly will start again and when will the plan be fully implemented?

Mr. SHULL. Sub-level assembly of missiles has begun in a number of areas. Full assembly operations are expected to be under way early in 1985.

MANUFACTURING IMPROVEMENT COSTS AT HUGHES

Senator QUAYLE. What do you estimate to be the total cost of the manufacturing improvements being made at Hughes Tucson facility?

Mr. SHULL. Costs associated with the Quality Review at Hughes Missile Systems Group arise from several different functions including Hughes' internal quality activities, extra government activity, and correction of possible workmanship or quality defects that may be found in the hardware. Per an Advance Agreement signed in mid-November, Hughes' exposure on some of these costs runs at least four years into the future. It is thus very difficult to determine final costs at this time. However, costs to Hughes are expected to be in the tens of millions of dollars.

Senator QUAYLE. Are these chargeable to a government contract?

Mr. SHULL. Provisions of the Advance Agreement do not permit charging these costs to a government contract.

QUALITY HORIZONS' FINAL REPORT

VOLUME I

QUALITY HORIZONS' STUDY TEAM

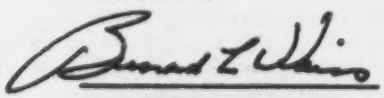
15 NOVEMBER 1979

OBSERVATIONS AND RECOMMENDATIONS TO ENHANCE PRODUCT QUALITY IN THE OPERATIONAL ENVIRONMENT

PREPARED BY:
THE QUALITY HORIZONS' STUDY TEAM
WITH REPRESENTATIVES
FROM HQ AFSC, HQ AFCMD, ASD and SAMSO

THIS QUALITY HORIZONS' STUDY REPORT REFLECTS THE OBSERVATIONS, FINDINGS AND RECOMMENDATIONS OF THE MEMBERS OF THE QUALITY HORIZONS' STUDY TEAM. THE REPORT DOES NOT NECESSARILY REFLECT THE POSITION OF AIR FORCE SYSTEMS COMMAND WITH REGARD TO THE ISSUES RAISED OR RECOMMENDATIONS PRESENTED.

APPROVED:



BERNARD L. WEISS
COLONEL, USAF
STUDY DIRECTOR

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I. EXECUTIVE SUMMARY

The Quality Horizons' Study was initiated by General Alton D. Slay, Commander, Air Force Systems Command, by letter dated 22 November 1978. The thrust of the study effort was to determine ways to enhance product quality in the operating environment. Study objectives were to evaluate the AFSC approach to quality assurance and identify changes with potential to: (i) improve end item quality in field use, (ii) make contractors more responsible for their products, (iii) make more effective use of resources, and (iv) apply appropriate commercial practices.

Major study efforts were started in January 1979 and completed in June 1979. Written progress reports were provided to General Slay throughout the study. Progress and final report briefings were presented to General Slay and his staff on 29 March 1979 and 1 June 1979, respectively. Prior to the final report briefing to AFSC/CC, the Product Division Commanders and the Commander of the Air Force Contract Management Division were briefed as to the team's observations and recommendations. Their concerns were included in the final report briefing and final report. The study team visited 66 selected governmental and industrial organizations in the United States and overseas. The following is a summary of the team's major observations:

(1) Attainment of field product quality is a function of the interest and priority placed on quality by top managers.

(2) Governmental and industrial organizations which have succeeded in obtaining high product quality levels, blend the assurance sciences into one high level organization which can act as a protagonist in causing tradeoff analyses and in assuring a disciplined integration of efforts to obtain product quality.

(3) Agreement exists that product assurance cannot be inspected into any product. Nevertheless, AFSC places more emphasis on conformance verification than attempting to influence product quality through design, process control and test planning early in the program life cycle.

(4) While various plans and programs have been implemented or proposed in DOD for reduced levels

of in-plant surveillance, program managers are generally reluctant to accept reduced in-plant Government quality assurance activities, especially conformance inspections.

(5) Commercial contracts are firm fixed price, with limited customer financing, and sole source follow-on buys are common with vendors that deliver a quality product at a reasonable price.

(6) In the commercial sector, warranties are generally offered only as a result of competitive pressures, such as in the commercial aircraft industry. Performance incentives and award fee provisions are almost never used in the commercial environment, either in the U.S. or overseas, nor do foreign governments employ them. Profits are their main incentive due to firm fixed pricing.

High levels of quality are obtained in the commercial sector where top management demands product quality or where competitive market pressures are such that the customer has an alternate source. General Slay, in Command Policy Letter 22, is on target with his drive for increased competition and use of firm fixed price contracts which adds impetus for enhanced product quality. Under firm fixed priced contracts, the full cost responsibility rests on the contractor's shoulders. The emphasis is on doing things right the first time.

The major recommendations of the Quality Horizons' Study Team are listed in summary form below. All recommendations are contained in the Action Plan (Appendix I) and discussed in Section V.

(1) AFSC must modify its current QUALITY assurance program to a PRODUCT assurance program to gain emphasis and attention to preventive efforts during design, development and test. AFSC's present program, while theoretically including preventive actions through a broad array of specialities, is heavily oriented toward in-plant conformance verification. The change in organizational concept and titles is necessary to reflect the increased emphasis on front end involvement by the requisite engineering and technical talents of the Product Divisions and AFCMD.

(2) In order to effectively implement the product assurance approach, it is recommended that all assurance disciplines, except manufacturing at AFCMD, be consolidated into one organizational element reporting

directly to the Commanders at all levels. This consolidation of skills is necessary to provide a critical mass of expertise and an organizational placement which will convert fragmented efforts toward product assurance to meaningful preventive actions and trade-offs.

(3) To motivate contractors to be more responsible for the quality of their products, the study team recommends selectively reducing the levels of in-plant conformance verification based upon a contractor's quality track record. A Minimum In-plant Surveillance (MIPS) program should be established where each contractor under AFPRO surveillance can make application for this reduced level of government surveillance. As the MIPS program proves successful, additional manpower can be reallocated to product assurance prevention efforts where greater returns from existing resources can be obtained.

(4) Positive actions must be taken to upgrade the training and education of the existing workforce and to provide for the orderly replacement of existing personnel through the establishment of a formalized three year intern program, geared to the skills necessary to perform product assurance in the aerospace community.

(5) Various recommendations are made in the area of contracting practices to support implementation and compliance with Policy Letter 22 and adopt, where feasible, existing commercial practices to enhance product quality. Specific recommendations cover the test of modified clauses which would restrict use of unilateral changes and modify procedures regarding point of final hardware acceptance. Other recommendations cover actions to reduce the level of Government financing of contracts, restrict progress payments, make greater use of award fee provisions and obtain authority to maintain two sources in production without a mobilization justification.

(6) A clear policy statement is required to support the use of contracting out to organizations (with hardware exclusion clauses) for selected product assurance functions requiring capabilities not available.

(7) The last group of recommendations emphasize the need for top management support to product assurance. A short, hard punching executive level training program is necessary to impart a sensitivity as to the benefits and risks of including or excluding product assurance considerations in Air Force programs. In addition, product assurance issues and actions should be made

part of various management and program reviews held within AFSC or at contractors' facilities. Providing product assurance visibility to managers will aid in enhancing product quality. Contractors sense Air Force priorities and react accordingly.

Improved product quality is obtainable for Air Force systems. The Quality Horizons' Team observed the results that management attention and investment have achieved in improving product quality in Japan and Europe. Similar results were observed in many commercial firms visited in the United States where product quality is a distinct customer requirement. Techniques and skills are available to obtain improved quality. They must be used early during the design and development process. The product assurance approach prevents deficiencies and can reduce the required in-plant defect detection and corrective action efforts. The impact of product assurance requirement trade-offs on field performance must be considered. With scarce resources, product assurance considerations may not always be supported. Nevertheless, decisions have to be made based upon predicted impacts, fund availability, performance requirements and delivery schedules. Product assurance, like other performance requirements, demands management attention and investment - "there is no free lunch."

II. STUDY REPORT

A. Study Approach Overview

Charter - The Quality Horizons Study was established by Alton D. Slay, General, USAF, Commander, Air Force Systems Command, by correspondence dated 22 November 1978, (Volume II, Section 1). The study directive was based on a plan developed by the AFSC Quality Assurance Office and approved by James W. Stansberry, Major General, USAF, DCS/Contracting and Manufacturing, (Volume II, Section 3). The study approach, (Volume II, Section 4) contains four main points:

1. Examine the concepts of contractor responsibility for end item quality and reduced Government in-plant presence and how these concepts could be implemented, managed and enforced in AFSC based on experience in various government, commercial and foreign settings. Consider programs for certifying contractor QA systems and personnel while assuring no degradation in end item quality.

2. Identify the type of contractual relationships which would provide strong positive or negative incentives that successfully place the responsibility for item quality with the contractor. Examine commercial practice for possible application in Air Force contracts.

3. Evaluate the qualifications of the AFSC QA work force and changes required in recruitment, training, education and assignment to strengthen the future work force.

4. Develop the proper QA organization structure and manning including the concept of a product assurance office, to implement changes resulting from the study.

It was assumed that there would be no increase in overall manpower that would result from recommendations contained in this study.

Team composition - Colonel R. C. Preston, Jr., Chief of Staff, HQ AFSC, was originally selected as the Study Director. However, prior to commencing the study, he was nominated for Brig Gen and reassigned. Col Bernard L. Weiss, Deputy for Contracting and Manufacturing, Aeronautical Systems Division, was named to replace Col Preston on 15 January 1979, (Volume II, Section 2). The ultimate team composition included:

Col Bernard L. Weiss
Deputy for Contracting and Manufacturing
Aeronautical Systems Division

Mr. Arthur A. Shannon
Deputy Director, Quality Assurance
Headquarters Air Force Contract Management Division
Mr. Shannon was Deputy Study Director

Mr. Donald W. Robinson
Director, Policy and Review
Deputy for Contracting and Manufacturing
Aeronautical Systems Division

Lt Col Michael M. McMillan
Chief, Aeronautical and Armament Division
Systems and Support Contracts Directorate
DCS/Contracting and Manufacturing, HQ AFSC

Lt Col Richard E. Tracey
Chief, Reliability and Quality Assurance Division
System Acquisition Management Support Directorate
ICBM Program Office
Space and Missile Systems Organization

Mr. Ira J. Epstein
Quality Assurance Engineer
Quality Assurance Office
DCS/Contracting and Manufacturing, HQ AFSC

Capt Raymond R. Honaker
Staff Quality Assurance Manager
Quality Assurance Division
Directorate of Manufacturing
Deputy for Contracting and Manufacturing
Aeronautical Systems Division

Capt John R. McNally
Manufacturing Staff Officer
Manufacturing Management Division
Directorate of Manufacturing
Deputy for Contracting and Manufacturing
Aeronautical Systems Division

Advisors to the study team included:

Capt C. B. Gresham, AFLC/JAN

AFSC Product Division Quality Assurance Directors

NSIA and AIA committees for Quality and Contracts

B. Study Approach - The team developed its assessment of the Command quality assurance program from the following sources:

1. A review of the results of previous studies with findings pertinent to the AFSC QA function.

2. Meetings and discussions with quality assurance professionals in government, industry, and professional organizations.

3. Briefings and discussions at each Product Division and AFCMD.

The team visited 66 government agencies and industrial firms in the United States, Japan, Germany, Denmark, Norway and Belgium. The industrial firms visited were engaged in work involving total commercial, total defense or a combination of the two. The government organizations visited included both DOD and civilian agencies. Each location visited (Tables 1 and 2) was provided a briefing (Appendix 2) to describe the intent of the visit and the reason for the AFSC study. The organizations visited usually provided a briefing on their view of quality assurance, their organization, and recommendations with regard to the team's study objectives. Following this, the team conducted an in-depth interview, concentrating on those unique aspects of the organization visited and innovations they had implemented or suggested for consideration.

Areas Examined - The team developed a questionnaire, (Volume II, Section 5) which was used during each interview to assure areas of consideration were not overlooked and to provide a more structured recording of their observations. The major areas of consideration were: organization/manning, education/training, quality-planning, quality measurement, subcontracting, contract requirements/warranties/incentives/guarantees, and field service. Summary highlights of the interviews are contained in Section IV, Study Observations. Details of each visit, such as completed questionnaires, copies of briefings and handouts provided are contained in separate trip folders for each visit.

Briefings Conducted - On 29 March 1979, General Slay and his staff were provided an interim briefing outlining the results of visits to that date and the principle observations. General Slay supported the briefing presented and highlighted the importance of the study effort. He offered no redirection. A copy of this briefing is contained in Volume II, Section 7.

Commanders of each of the AFSC Product Divisions (ADTC, ASD, ESD and SAMSO) and AFCMD were provided briefings on the results of the study. Their comments, (Volume II, Section 8) were considered in developing the final briefing to General Slay on 1 June (Volume II, Section 9).

Progress Reports - General Slay was provided bi-weekly progress reports, (Volume II, Section 6). The progress reports summarized the major observations made during each reporting period.

ORGANIZATIONS VISITED

(United States)

COMMERCIAL

MILITARY PRODUCTS*

Bendix	Honeywell

COMMERCIAL PRODUCTS

Western Electric	Bell Labs	RCA Avionics
Sears	Quasar	Gates Lear Jet

COMMERCIAL & MILITARY PRODUCTS*

Texas Instruments	Hughes	Northrop
Cleveland Pneumatic	Boeing	Douglas
General Electric (Aircraft Engine Group)	Beech	TRW
	Cessna	

GOVERNMENT

HQ USAF
Office of the Secretary of Defense (OSD)
HQ Defense Logistics Agency (DLA)
Electronic Systems Division (ESD)
Armament Development Test Center (ADTC)
Space & Missile Systems Organization (SAMSO)
Air Force Contract Management Division (AFCMD)
HQ Federal Aviation Administration (FAA)
National Aeronautics & Space Administration, Houston (NASA)
Federal Aviation Administration (NW Region)
Defense Contract Administration Services, Atlanta
HQ AFSC/SDD
Aeronautical Systems Division (ASD)
Naval Material Command (NAVMAT)
Naval Air Systems Command (NAVAIR)
US Army Development and Readiness Command (DARCOM)

OTHER

Airline Representatives:

Southwest	American	United

National Security Industrial Association (NSIA)
Aerospace Industries Association of America Inc (AIA)
Electronic Industries Association (EIA)
ARINC

*Included visit to CAS Office

TABLE 1

ORGANIZATIONS VISITED
(Overseas)

JAPAN

COMMERCIAL PRODUCTS	COMMERCIAL & MILITARY PRODUCTS
Ricoh Company	Nippon Electric
Nissan	Mitsubishi
Nippon Steel	

GOVERNMENT AGENCIES

US Embassy Mutual Defense Office
Central Procurement Office
Technical Research Development Office

OTHER

Union of Japanese Scientists & Engineers (JUSE)

GERMANY

COMMERCIAL & MILITARY PRODUCTS

LITEF (Litton Technische Werke)
MBB (Messerschmitt Bolkow - Blohm)

GOVERNMENT AGENCIES

Det 16/AFCMC
Federal Ministry of Defense

DENMARK

COMMERCIAL PRODUCTS	COMMERCIAL & MILITARY PRODUCTS
Bruel & Kjaer	Standard Electric

GOVERNMENT AGENCIES

US Embassy Office of Defense Cooperation
Ministry of Commerce
Royal Danish Air Force Air Material Command

NORWAY

COMMERCIAL & MILITARY PRODUCTS

NEBB (Norsk Elektrisk & Brown Boveri)
Kvaerner
Kongsberg KV

GOVERNMENT AGENCY

Defense Combined Material Agency (DCMA)

BELGIUM

COMMERCIAL & MILITARY PRODUCTS

MBLE (Manufacture Beige DeLampes Et De Materiel Electronique)

GOVERNMENT AGENCIES

Contract Administration Services Europe (CASEUR)
Ministry of Defense (MOD Belgium)

TABLE 2

III. CURRENT AFSC APPROACH

In order to set the stage for recommendations to enhance quality assurance functions in Air Force Systems Command, we must briefly review our current approach. This review covers the major organizations involved in quality assurance.

A. Laboratories

AFSC Laboratories are primarily involved in basic research and development. Product quality assurance is not normally an element of major concern either for in-house development work, research, exploratory system or equipment development contracts. If appropriate, contracts for research or exploratory development contain requirements for the contractor to establish and implement a quality assurance program tailored to fit the given situation. Checklists used by the laboratory to develop procurement requests contain an item associated with quality assurance, which serve to ensure that quality aspects of the pending procurement are considered. In general, however, there are no formalized procedures in the laboratories related to a quality assurance program for in-house work or for contracted efforts.

There are no quality assurance engineers, technicians, or managers assigned to the laboratories. However, there are laboratory engineering and technical personnel knowledgeable in the area of nondestructive testing (NDT) who are available and provide consultation and QA support to program offices. The Air Force Materials Laboratory (AFML) is the USAF focal point for developing new or advanced NDT equipment.

Quality assurance training courses, offered within the DOD, are available to laboratory personnel. However, lab personnel have generally not availed themselves of such training opportunities. Training on non-destructive inspection equipment and techniques is presented by AFML personnel to AFSC and AFLC personnel, on a request basis.

Typical laboratory contracts for research or exploratory development work result in final reports, analyses, or recommendations; not hardware. Where an item of hardware is required, it is usually one of a kind. The contractor generally has sole responsibility for the end item. In-process inspection, testing, or final acceptance, under a formal quality assurance program are not accomplished.

B. Product Divisions

Each AFSC Product Division has taken action to implement AFSCR 74-1, Quality Assurance Program, which requires the quality assurance function to be actively involved in all phases of the system acquisition process. Although approaches and effectiveness vary among divisions, each has assigned a Quality Assurance Manager (QAM) to its larger programs, and each has provided for some degree of staff support for the QA functional area. As a group, the QA leaders at each product division are supporting efforts of the command Quality Assurance Office (AFSC/PMN) to improve the effectiveness of QA through activities such as the "Quality 79" management objectives program and the preparation of guidebooks for QA management and for application and interpretation of MIL-STD-1520A, Corrective Action and Disposition System for Nonconforming Material, and MIL-STD-1535A, Supplier Quality Assurance Program Requirements. This group is also involved in the improvement of QA-related specifications, standards, and acquisition regulations. Through these activities the AFSC quality assurance community has been working cooperatively to increase the positive impact of QA disciplines on the acquisition process.

SAMSO has a centralized QA staff of 5 in the Directorate of Manufacturing and Quality Assurance within the Deputy for Contracting and Manufacturing. There are additional full-time and part-time QA Managers (QAMs) or points of contact in the program offices for a total of 2 full-time equivalents. SAMSO contracts with Aerospace Corporation for 31 product assurance personnel (6 QA, 11 Reliability and 14 Parts Control) and TRW Systems for 21 product assurance personnel (4 QA, 9 Reliability and 8 Parts Control). This supplemental support provides specialized skills to the SAMSO product assurance management and staffs. The ICBM Program Office, SAMSO's largest SPO, has located its QA function in the Acquisition Management and Systems Support Directorate. The QAM is part of the Reliability and Quality Assurance Division of that Directorate and is supported by the full-time TRW QA personnel included above.

The ADTC QA function is in the Manufacturing and Quality Assurance Directorate within the Deputy for Contracting and Manufacturing. There are 14 QA manager/engineer positions which support armament systems acquisition and 4 QA specialist positions

involved in administration of secondary delegations. ADTC also has 8 QA technicians in the Test Wing who perform technical surveillance of range operation services. The responsibility for reliability, maintainability, test, configuration management, program management and engineering is assigned to the Deputy for Armament Systems.

The ASD QA focal point is the Quality Assurance Division in the Directorate of Manufacturing within the Deputy for Contracting and Manufacturing. The QA Division is the responsible staff office for QA management using the ASD matrix management concept. The quality engineering function at ASD is matrixed out of the Engineering Specialities Division within the Deputy for Engineering. ASD has 29 full-time QA positions authorized, of which 8 are designated as QA Engineers (QAEs). In ASD, collocated QAM and QAE personnel work under the direction of the senior collocate, such as Chief of Manufacturing or Chief Engineer, and therefore are an integral part of the program organization. The staff offices in this arrangement provide resources, policy guidance, and assistance to collocated personnel.

At ESD, the quality assurance focal point is one individual located in the Systems Engineering Directorate within the Deputy for Technical Operations. A second full-time QA specialist is assigned as the QA manager for the E3A and E4 programs. Remaining QA activities are accomplished by part-time personnel.

C. AFCMD

The basic mission of AFCMD is to support Program Directors by performing the standard contract administration functions of DAR 1-406 and additional functions contained in Memorandums of Agreement per DAR 20-703. Historically, AFPRO activities have provided QA appraisals to the program office through their in-plant presence, control, and visibility. In the early 1970s, it became obvious to AFCMD management that many program problems which absorbed a great deal of problem-solving manhours and dollars were caused by basic deficiencies in contractor management systems. In an effort to do a better job with less resources, AFCMD embarked on a program to change the alignment of their mission so as to emphasize management systems evaluation.

The Contractor Management System Evaluation Program, CMSEP, treats contractor management as a system, and, in an orderly way, evaluates the system for existence, for adequacy, and for compliance. At each AFPRO, CMSEP is a continuous process of testing the management system and sampling its outputs. The program tasks which each AFPRO continues to perform in support of the Program Director thus become a part of the CMSEP continuous evaluation process.

CMSEP has affected the AFCMD quality assurance function in a number of ways. First, since CMSEP is oriented to prevention of problems, it changed the balance between QA appraisal effort and QA prevention effort. More manhours are directed at procedural issues and quality planning matters and less effort on direct inspection of products and processes. Secondly, CMSEP caused quality assurance responsibilities to be allocated to other functional AFPRO elements including Manufacturing, Subcontract Management, and Engineering. With this reallocation of responsibility, the QA element diminished in size and in stature. On the other hand, all AFPRO functions now have an active part to play in achieving QA objectives, and have a better appreciation for the QA requirements and their contribution to program success.

The current AFCMD QA work force strength is 1,184. This total includes all manpower positions in the QA function at the Headquarters and at the Detachments. Since 1968, AFCMD manpower has been reduced by 15% from 3,993 to 3,389, while the quality assurance work force has been reduced by 32% from 1,741 to 1,184. Of the total AFCMD reductions (604 manpower positions), 92.2% (557 manpower positions) were in the quality assurance function. This magnitude of reduction has caused AFCMD to move from a concept of individual defect detection to a systems survey approach with more reliance placed on the results of the contractor's inspection efforts.

The majority of the employees assigned to the quality assurance function do not have college degrees. Thirty percent of the employees have some college education (less than a Bachelor's degree) and 15% have a Bachelor's degree or higher. This mix of education is a direct reflection of the type of functions performed by the quality assurance specialists in the past.

Forty-two percent of AFCMD's effort, based on contract dollar value, is in support of non-AFSC contracts, principally NASA and the Navy. NASA procurement regulations require that they use the DOD component that has been assigned plant cognizance. DOD Instruction 5030.42, "Performance of Contract Administration Services and Contract Audit Services in Support of NASA Contracts", contains the NASA/DOD Agreement that DOD CAS personnel will accomplish Procurement Quality Assurance for NASA. This support is normally the direct inspection of product parameters deemed important by NASA. While there is a certain amount of benefit to NASA as a result of CMSEP, normally NASA desires only mandatory product inspection. When AFCMD has plant cognizance, it provides the same quality assurance program for Navy contracts as for USAF contracts.

D. HQ AFSC

The current AFSC quality assurance organization was established in October 1977 by Maj Gen Stansberry as a result of the Quality '77 Study. The Quality Assurance Office reports directly to the DCS/Contracting and Manufacturing who reports to the Commander, AFSC. The office is authorized five professional spaces and one clerical space. The current chief is a Lt Col (an 0-6 is authorized). The office is primarily responsible for establishing AFSC quality assurance policy. The policy is contained in AFSCR 74-1. The office operates primarily in a management by objectives mode. AFSC quality assurance objectives are published and distributed to all first level field AFSC quality assurance organizations. Field organizations are assigned actions to support AFSC objectives. Examples of ongoing efforts are: training, career development, software quality assurance, quality technology program (Q-TECH), quality assurance program for ranges and test centers, programs for laboratories and for base contracting, incorporating quality assurance requirements into appropriate regulations and handbooks and asserting pressures to increase quality assurance manning. The Quality Assurance Office has no responsibility for reliability, maintainability, configuration management, test or other functions which have a direct effect on product quality. These functions are assigned to other organizations in AFSC.

IV. STUDY OBSERVATIONS

A. Organization/Manning

Organizations for quality vary considerably as do organizational titles. Titles range from Quality Control to Quality Assurance to Product Assurance to Product Effectiveness to Systems Effectiveness and others. The organizations varied depending upon customer requirements, product line and responsibilities considered important by management. For example, if customer requirements include reliability, there would be a reliability organization, often integrated with the quality organization. As the product line becomes more sophisticated, there are more quality engineers, reliability engineers and other professionals in the organization. As product liability, product criticality, cost, warranty provisions and customer expectations increase, organizations for field support increase.

One U.S. firm, in direct competition with Japanese industry in a high technology product line, has been able to capture and maintain a significant share of the market. They attribute much of their success to the synergistic effect of combining the assurance disciplines at the top management level. Similar successes, based on similar organizations, were observed in other U.S. commercial firms. There appears to be a trend throughout industry and the Government toward combining many of the functional disciplines into the same organization to take advantage of their related influences on product quality and reliability. Those industrial firms and Government agencies organized in this way felt that it provided a much better utilization of resources since the same individual could perform several related tasks that were previously fragmented among different functional disciplines. They also felt it resulted in a program-oriented attitude rather than the compartmentalized thinking that the old fragmented organizational structure encouraged.

The study team observed that no two AFSC Product Division organizations are organized the same. In fact, there is not even any similarity between the HQ AFSC organization and that of the Product Divisions. Consequently, the assurance discipline organizations receive guidance from a variety of HQ AFSC staff offices. This fragmentation contributes to the lack of a strong voice in making program decisions and hinders the development of a unified product assurance position

that would maximize program benefits. Figures 1 thru 5 show the organizational placement of those functional disciplines in the AFSC Product Divisions and AFCMD that are often included in an integrated organization such as product assurance. These Figures emphasize the multiple lines of communication that exist between HQ AFSC and the division levels.

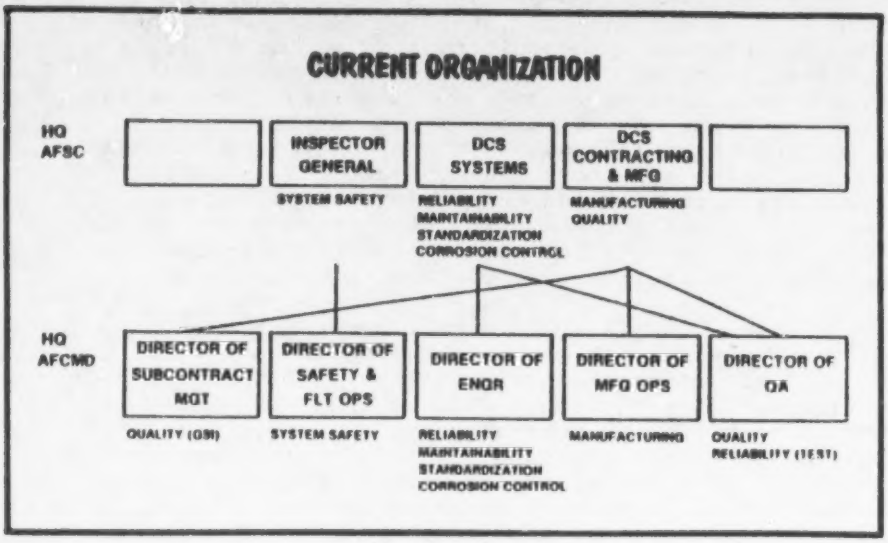

FIGURE 1

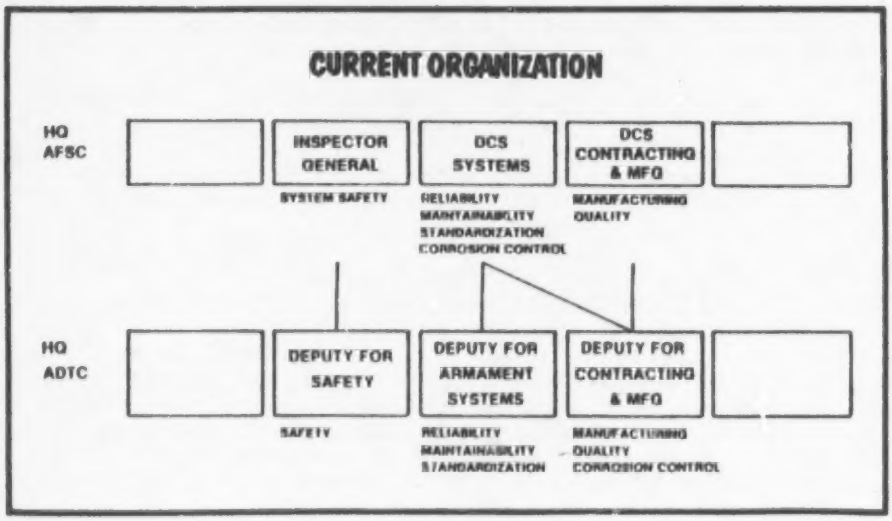

FIGURE 2

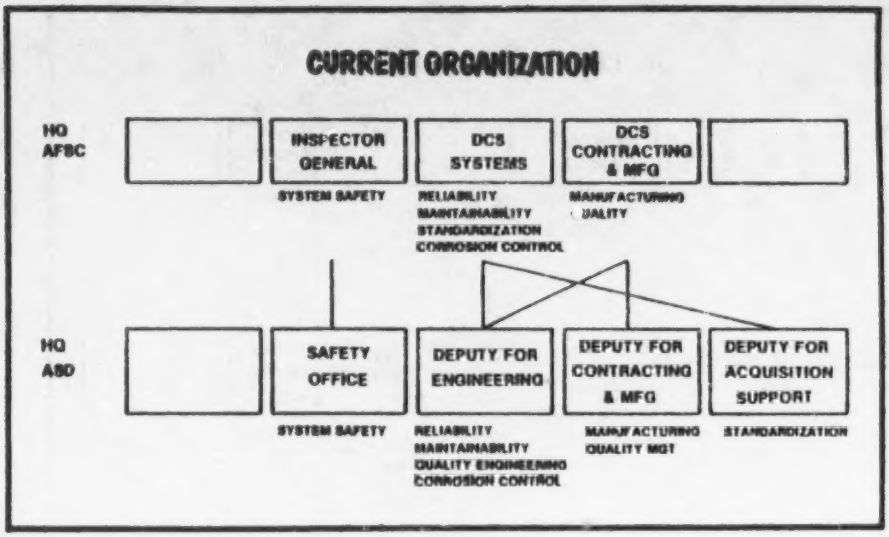

FIGURE 3

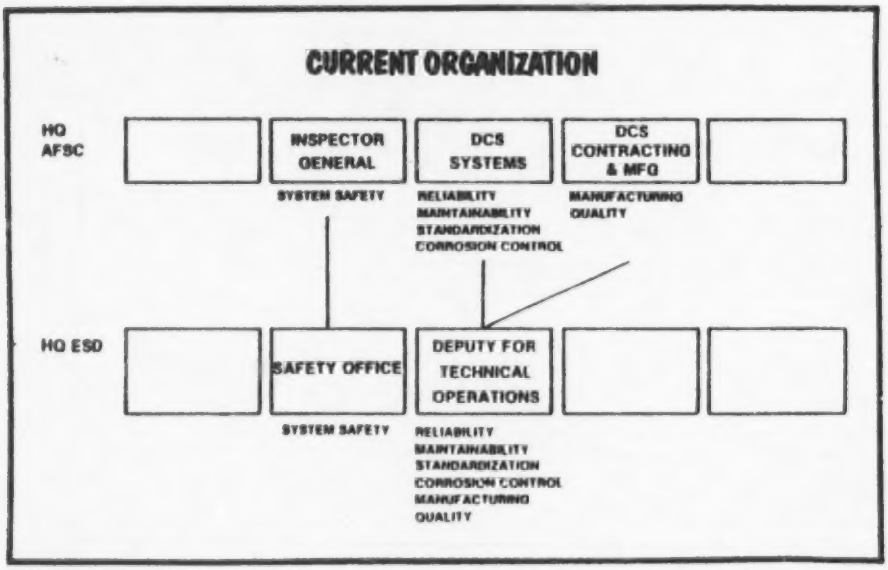

FIGURE 4

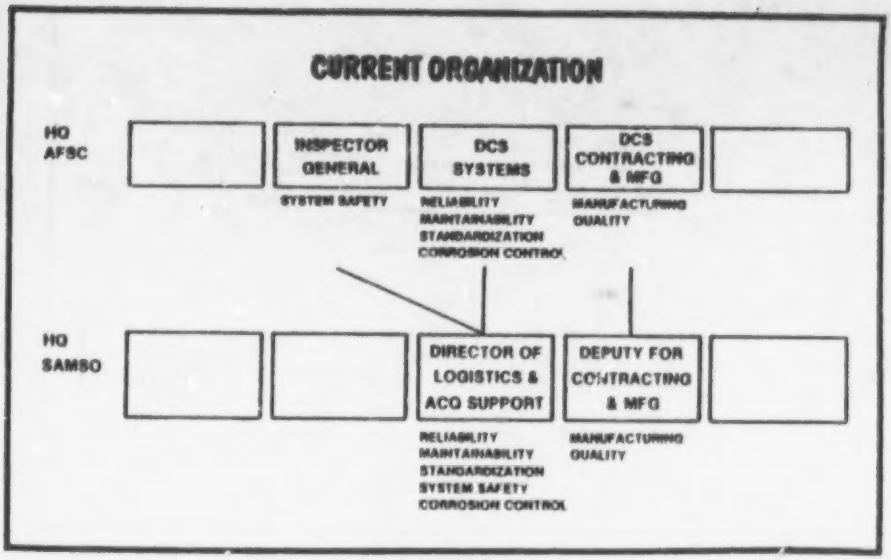

FIGURE 5

Table 3 shows the total number of personnel currently involved in product assurance disciplines in AFSC. These numbers represent those portions of the listed organizations that actually perform product assurance functions as defined in Section 5.

CURRENT PERSONNEL INVOLVED IN PRODUCT ASSURANCE

	HQ AFSC	ADTC	ASD	CHD	ESD	SAMSO
Manufacturing	31	24	149	70	50	22
Quality Assurance	6	14	29	1184	8	12
Engineering	7	18	55	190	13	23
System Safety	8	13	19	0	4	2
TOTALS	52	69	252	1444	75	59

GRAND TOTAL - 1951

TABLE 3

In most industrial organizations, where top management felt quality was important, quality management reported directly to the top operating official. In U.S. defense contractor organizations, quality is independent of the manufacturing organization and reports directly to the top operating official.

In Government agencies visited in the United States, the quality organizations and their level in the overall organization also varied. In the Naval Material Command (NAVMAT) (Figure 6), the Deputy Chief of NAVMAT for Reliability, Maintainability and Quality is a GS-16 and reports directly to the NAVMAT Commander (O-10). Each of the Naval Systems Commands below NAVMAT has a quality organization. At that level, the organizations are not uniform. A matrix concept is utilized. There are several GS-15s in the various Naval Systems Commands quality organizations. There are over 7,200 personnel in the Navy's quality career program, of which 6,200 are in NAVMAT.

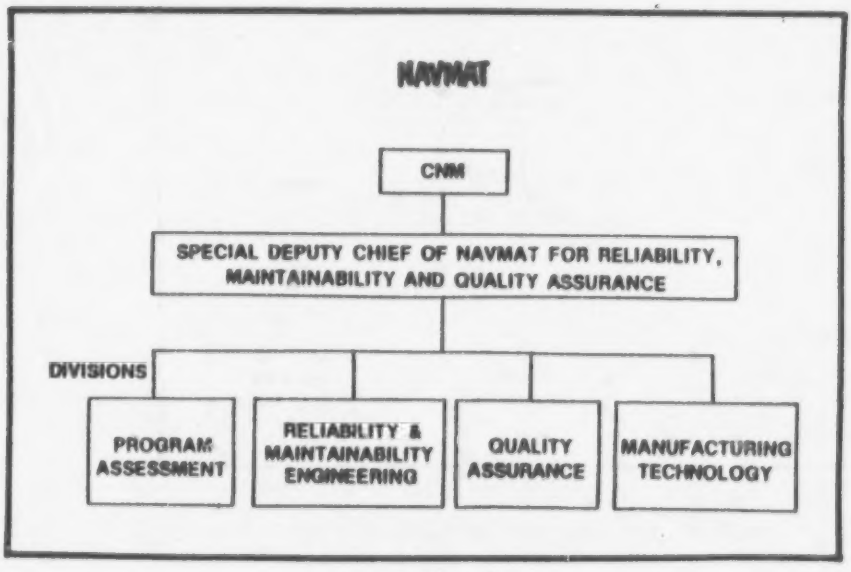

FIGURE 6

The Army has a strong and disciplined organization for quality. It is headed by a GS-16 who reports to the Commander (0-10) of the Development and Readiness Command (DARCOM) (Figure 7). Each subordinate product command has a quality assurance organization for development and another for readiness, generally headed by a GS-15. The quality assurance work force in DARCOM is over 5,600 people. They too, are matrix managed. DARCOM's product oriented Development Commands and Readiness Commands use the program manager concept like AFSC. There are, on the average, four to five quality assurance personnel assigned to each program office. The Chief of Quality Assurance in larger program offices is a GS-15. In smaller program offices, the position is generally a GS-14. Quality Assurance in DARCOM includes the reliability function. Quality is organized to assure/assess quality at all phases of the acquisition cycle including deployment.

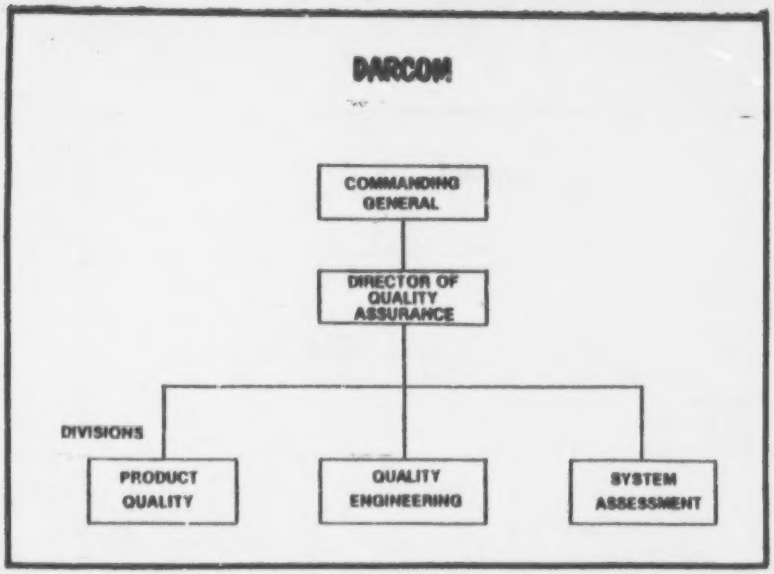

FIGURE 7

NASA's Johnson Space Center (JSC) has a quality organization which includes reliability and safety. There are 365 personnel in this organization which include 199 contractor support personnel. The Director of Safety, Reliability and Quality Assurance is a GS-17 and reports directly to the JSC Director. JSC is also matrix managed.

DCAS is organized somewhat differently since their function is solely contract administration. The quality assurance organization has about 6,500 people. The Executive Director of Quality Assurance is a Major General with a GS-16 Deputy. Regional Quality Assurance Directors are Colonels or GS-15s.

In contrast, HQ AFSC has a small quality assurance staff of five professionals headed by a Lt Col (Col position authorized). This staff is two organizational levels below the AFSC Commander. Most of the quality assurance personnel in AFSC are in AFCMD. The quality assurance organization in AFCMD is headed by a Lt Col (Col position authorized) who reports directly to the Commander. There are 1,184 quality personnel in AFCMD. The grade level of the AFPRO Quality Assurance Division Chiefs is GS-13 or GS-14. In all AFSC Product Divisions, except ESD, the quality organization is three levels below the Commander reporting to the Deputy for Contracting and Manufacturing. At ESD, quality assurance is also three levels below the Commander but under the Deputy for Technical Operations. Quality assurance manning authorized in program offices and product division staffs is: SAMSO - 8; ASD - 29; ADTC - 14; and ESD - 5. ASD and ADTC are matrix managed. The typical grade of a quality assurance manager assigned to a major program office is a GS-12/Captain. Some program offices do not have full-time quality assurance personnel assigned. The top quality assurance individual in the Product Divisions is a GS-13 or GS-14.

There appears to be a direct correlation between the influence of the quality assurance organization on management/program decisions and the grade of the quality assurance individual and his level in the organization. In U.S. companies, quality considerations are voiced; however, the final decision is usually a matter of negotiation and trade-off between cost and schedule. In Europe, quality appeared to be more influential and would normally not be sacrificed for schedule considerations. In Japan, quality factors normally dominated management decisions. The Japanese often sacrifice schedule and cost to attain high quality.

Quality assurance in the Army and NASA have an independent and equal voice with other functional organizations in program decisions. In AFSC, the QA organizations are normally too low in the overall organization to be influential. Quality assurance has neither an equal nor independent voice in program decisions because of their low organizational placement at the branch level (occasionally division level).

Although the QA capability in product divisions has been increasing over the past two years, it is not at a level sufficient to ensure that acquisition strategies and requirements trade-offs which generate program quality risk are given appropriate consideration prior to program decisions. Contributing to this are a lack of resources - both numbers and capabilities, the organizational location, and program management attitudes towards quality assurance.

Table 4 shows the typical quality assurance staffing of the various locations visited. Table 5 indicates how U.S. and foreign governments are manned in contract administration organizations to perform the quality assurance function. Tables 6 and 7 summarizes the organizational placement and grade levels of quality assurance organization in U.S. and foreign government agencies.

QA STAFFING

U.S. CONTRACTORS

GENERALLY AROUND 10% OF WORKFORCE
- INSPECTION AND TEST

LESS THAN 1% FOR SUBCONTRACTING

U.S. GOVERNMENT AGENCIES

APPROXIMATELY 10% OF CONTRACTOR's QA STAFFING
APPROXIMATELY 35% OF CAS STAFFING - ALL CIVILIAN
PRODUCT DIVISION VERY LIMITED (LESS THAN 1%)
- OFTEN ADDITIONAL DUTY

FOREIGN CONTRACTORS

APPROXIMATELY 10% OF WORKFORCE
- INSPECTION AND TEST

FOREIGN GOVERNMENT AGENCIES

APPROXIMATELY 10% OF CONTRACTOR's QA STAFFING
FROM 25% TO 100% OF CAS STAFFING
MULTIPLE RESPONSIBILITIES
SOME ARE ALL MILITARY

TABLE 4

DEFENSE QUALITY ASSURANCE STAFFING
(PERCENT OF CAS PERSONNEL)

U.S. (DCAS, AFPRO, NAVPRO)	35% (ALL CIVILIAN)
JAPAN (CPO)	40% (MOSTLY MILITARY)
GERMANY (BWB)	25% (ALL CIVILIAN)
DENMARK (AMC)	100%* (ALL MILITARY)
NORWAY (DCMA)	53% (ALL CIVILIAN)
BELGIUM (BAF/CAS)	100%* (ALL MILITARY)

*FIELD PERSONNEL PERFORM MULTIPLE FUNCTIONS

NOTE: AFSC PRODUCT DIVISIONS - LESS THAN 1% OF TOTAL WORKFORCE

TABLE 5

QUALITY ASSURANCE ORGANIZATIONAL PLACEMENT

UNITED STATES	LEVELS REMOVED FROM TOP MANAGER	COMPARABLE GRADE
HQ AFSC	TWO	COL
PRODUCT DIVISIONS (STAFF)	THREE	LT COL/GS-14
SPOs (ADDITIONAL DUTY)	TWO TO FOUR	CAPT/GS-12
CMD	ONE	COL
DCAS	ONE	MAJ GEN
ARMY	ONE	GS-16
NASA/JSC	ONE	GS-17
NAVY	ONE	GS-16

TABLE 6

QUALITY ASSURANCE ORGANIZATIONAL PLACEMENT

OVERSEAS	LEVELS REMOVED FROM TOP MANAGER	COMPARABLE GRADE
JAPAN (CPO)	ONE	SUPERGRADE
GERMANY (MOD)	FOUR	SUPERGRADE
DENMARK (AMC)	TWO	GS-14
NORWAY (DCMA)	ONE	GS-14
BELGIUM (BAF/CAS)	ONE	COL

TABLE 7

B. Quality Planning

It was observed that quality planning for commercial products begins by developing design criteria which is often published in company handbooks or procedures manuals which supplement industry standards. These efforts reflect experiences, lessons learned and proven techniques for assuring the inherent reliability and quality of the design. A significant aspect of this early involvement for design assurance is the use of a parts, materials and processes (PMP) standardization and control program. The more complex and critical the product, the more disciplined the use of PMP tools and techniques such as derating, parts application review, etc. A rational application (tailoring) of these tools is used and is based on program requirements as needed to support a cost effective program and the business strategy approach selected.

One commercial firm was able to reduce the number of rejects during the manufacture of its product from twice per item to less than 10 rejections per 100 items manufactured. They did this by management demanding a disciplined approach to quality planning. For example, the parts count was significantly reduced; derating criteria used; parts, subassemblies and assemblies screened and tested at each level; and labor intensive operations automated.

AFSC organizations generally do not have as disciplined an approach to assuring design quality. One notable exception is SAMSO, who relies on contracted support in this area. SAMSO feels very strongly that an effective PMP standardization and control program contributes more to product reliability than any other factor. They contractually impose quality planning factors such as derating criteria, parts application reviews, critical item and baseline controls. Even then their experience has shown that extensive monitoring and review of the contractor's efforts in these areas are required to prevent catastrophic problems. Through their close technical involvement with the contractors they are able to minimize cost, schedule and performance impacts. SAMSO's efforts in this area closely parallel the study team's observations of successful industrial firms producing comparably complex equipment. SAMSO as well as many commercial firms have experienced serious quality and reliability problems when the application of these tools and techniques has been lax or omitted, e.g., the Minuteman weld problem, TITAN booster failure, etc.

The other AFSC Product Divisions have not tended to impose these same contractual provisions, nor do they have the same expertise, e.g. parts engineers to develop or monitor their contractors' performance in these areas. Thus, they are forced to rely upon contractors to develop their own programs, design criteria, et cetera. Even then the program offices and CAOs are limited in their ability to monitor the contractor's performance in achieving these goals (not requirements) due to the lack of skilled manpower in these disciplines.

An often neglected quality planning function in AFSC has been the early involvement of quality engineers. Quality engineers influence design by assuring that the design accurately reflects the requirements, that lessons learned have been incorporated, that the design is repeatedly producible, and that meaningful inspections and tests are both possible and planned. Many companies, expecially the Japanese, perform these tasks and feel they provide a very cost effective defect prevention function.

Another important aspect in assuring the reliability and quality level of the product is to freeze the baseline when the design has been proven. After the baseline is established any changes can be completely analyzed or hardware retested to determine possible impacts on quality and reliability. During initial design analysis, contractors in the commercial sphere thoroughly evaluate vendor designs to determine the level of involvement and controls that will be needed to assure vendor performance. AFSC program offices often are not manned with sufficient or trained personnel to perform this effort.

In the commercial sector, firms tend to rely on evolutionary product improvements. Quantum changes generally occur only when technology advances have been proven. Product improvements are generally made to correct specific problems in the design or manufacturing processes, and the impact of these changes on reliability and quality are evaluated. Extensive preproduction testing is performed to assure that the design is producible and will perform as intented in the field environment.

Whenever specific product quality and reliability levels are required by the customer, verification testing is considered almost sacred. Only by such testing at all levels; i.e., part, subassembly, subsystem and system level, can a manufacturer have confidence

that the design will perform as intended. They recognize that design is an iterative process and seldom if ever will they produce a perfect design the first time even though they incorporate all currently known techniques. Unexpected problems can occur and may not be detected until the item reaches service. Thus, every attempt is made to subject the design to the anticipated worst case stresses to promote test failures. These failures are then analyzed to determine the cause so that preventive actions such as redesign, derating, circuit protection, etc., can be taken. Successful commercial organizations have found that numerous field failures are the direct result of failing to perform these vital functions adequately. Therefore, the product does not enter production until the manufacturer is confident that it is suitable and reliable.

In contrast, because of operational requirements, AFSC tends to push state-of-the-art advances in many areas simultaneously. Not only does AFSC require and support significant advances in performance with each new product, but tries to use the most advanced technologies and materials in manufacturing these products. As a result of these simultaneous learning curves, problems not only in performance and producibility occur, but major deterrents to quality are introduced. First, failure modes are introduced by not having fully matured the manufacturing process or by not understanding the problems such a process introduces. Thus, these failure modes are not recognized until equipment starts failing in the field. Problems in perfecting these new techniques and materials cause schedule delays and cost impacts which often result in cancelling the preproduction testing that could have identified these problems. The irony is that when these inherent problems are not identified and eliminated early, then the schedule and cost impacts tend to be even greater. Such schedule and cost impacts further encourage shortcuts and the introduction of even more problems, and the vicious circle continues. Thus, the more a new product advances technology and performance, the greater the need for the application of product assurance principles and techniques, yet the more likely they will not be used due to cost and schedule considerations.

Directly related to quality planning is accomplishment of the various program technical and management reviews. Those companies and government organizations that have been most successful have placed heavy emphasis on these efforts. Industry performs extensive analyses

of their manufacturing capabilities to assure that these capabilities are compatible with the requirements. They strive to balance the inherent capabilities and requirements by either improving the capability or reducing the requirements to an achievable level to assure that risks have been minimized. Program management is kept apprised of the evaluation results from which they can make program decisions based on risk assesments. Also included in their manufacturing capability and design analyses are the identification of critical aspects of manufacturing processes and procedures. These critical features either receive additional design analyses or controls are developed to assure that the manufacturing process will consistently result in a conforming product. This same attention is given to those aspects determined to be cost drivers. Inspection points including mandatory requirements are also determined during these analyses. Although all AFSC programs have similar reviews, such as critical design and production readiness, they are often performed by untrained and inexperienced personnel and in an undisciplined manner.

One aspect that is peculiar to the AFSC organization is the interface between the product divisions and the contract administration organizations (CAOs). Manpower limitations and organizational parochialism have often prevented the program offices and CAOs from developing a full and complete mutual understanding of the contract requirements, interrelationships, and a detailed and specific memorandum of agreement. Thus, CAOs often do not realize the program office's requirements or cannot support them with either skills or manning resources by the time these requirements are finally known. The program offices likewise are unaware of the unique capabilities of the supporting contract administration offices. Consequently, each organization independently works its own problems rather than mutually developing a team spirit in support of the program. Effective communications can be hindered and the contractor could end up receiving conflicting guidance or direction. Directly related to this is the unjustified establishment of mandatory product inspection requirements. These are often imposed by the program offices without any coordination with the CAOs. This could result in requiring needless inspections, omission of important requirements, or the inability to participate in various design reviews due to manpower limitations.

As seen in the commercial sector, industry's overall emphasis in the design area is on early failure analysis and defect prevention. AFSC programs invariably end up in a defect detection mode. The only way to avoid this is by early involvement by skilled quality, reliability, parts, etc., personnel concerned with product assurance requirements that will satisfy user's needs. These people must assure that the proper tools and techniques have been effectively and efficiently tailored and incorporated into the contract. This effort and the subsequent monitoring of the contractor's performance requires an appropriate level of manning and funding. Failure to assure an adequate level of manning and proper training invariably results in a reactive mode of problem tracking rather than failure prevention.

C. Quality Measurement

Measurement of quality begins by determining the contractor's quality of design, his capability to produce the product as specified and the effectiveness of his quality assurance program to assure conformance. Industrial firms engaged in development of commercial products tend to concentrate on these functions with their suppliers, recognizing that a vendor's capability and expertise truly determine the end product quality, reliability, schedule adherence and product cost. Their evaluation of a vendor is an in-depth, in-plant analysis by a team of specialists skilled in this function. They evaluate the vendor's total capability for producing and controlling the product's conformance to the requirements. They also consider a vendor's past performance as a strong indication of how he will perform on future contracts. Industry tends to select the best performers even though they may not be the lowest in initial cost.

AFSC has tended to place more emphasis on the lowest cost proposal due to the potential for protests, although more emphasis is being placed on past performance criteria of late. AFSC evaluations of a contractor's capability, quality assurance system and quality management are often performed only by evaluating the contractor's Quality Assurance Program Plan during source selection. Often the leverage to incorporate needed changes to the contractor's system is lost because these problems are not detected while still in a competitive environment. This results from a failure to fully evaluate the actual system because of a lack

of skilled personnel to perform the evaluation. After contract award, such changes are difficult to implement even though the contractor's system is obviously deficient and the change will result in improved quality and contractor efficiency.

Industry measurement of quality in the commercial market area is achieved in many ways. Vendor's rejection rates are tracked, i.e., incoming inspection, failures during assembly, costs of rejects, etc. They also measure the product's performance in the field (e.g., maintenance delays, aborts, in-flight shutdown, warranty returns, spares usage rates, etc.). These problems are not only analyzed for cause and failure trends, but they are also fed back to the vendor and corrective action is required.

In AFSC there is no primary system or responsible organization for collecting quality data. The CAOs are responsible for reviewing yield rates, excessive reworks, etc. and can identify the need for corrective action, yet the program office usually retains the authority to direct the contractor to make changes. Even if the CAOs provide the program office with visibility as to pre-acceptance quality performance levels, the information is generally untimely for corrective action. Field quality data is collected under several different and unrelated systems by different organizations. Quality deficiency reports are completed by the users on field equipment and submitted to the appropriate Air Logistics Center which usually does not have the authority to direct the contractor to do a failure analysis or take corrective action. During RDT&E, these deficiency reports are submitted to the program offices, but not necessarily to the CAOs. Spares usage rate reporting is also the responsibility of AFLC. Post acceptance aging and surveillance as well as reliability data are generally the responsibility of the program office.

There are significant differences between the way industry and the government deal with their suppliers who are having problems. Both send in teams to work the problems with the manufacturer. Industry tends to emphasize problems and their performance requirements, whereas the Government tends to direct how to resolve the problem and how to achieve the performance. Industry feels this causes unnecessary costs, denies them design latitude, relieves them of responsibility and makes the Government a direct party to any subsequent problems. Many government personnel feel that

this is a more economical approach, especially on cost type contracts in that lessons learned can be incorporated and standardization benefits realized. Both positions have some merit. Of major interest is the difference in the manner in which problems are worked by these two different approaches. In the commercial environment, industry seems to accept the fact that unforeseen difficulties may arise and that omissions and errors will be made. Therefore, they join forces to resolve the problem and prevent recurrence. The vendor is motivated to be cooperative in order to retain his market with the prime and the prime is motivated to retain a capable and experienced vendor. Their objectives are to assure customer satisfaction and make a profit.

Several industrial firms felt that the atmosphere in the DOD environment with respect to joint government-contractor problem resolution seems to be adversary. Each party seems more concerned with establishing blame and liability than achieving the proper problem resolution. This adversarial relationship is created in part by a success-oriented attitude and unrealistic expectations that do not recognize or allow for cost or reliability growth.

Since commercial enterprises often assume responsibility for product quality in the field environments through warranties, customer expectations, or product liability, they develop whatever data system is required to fulfill these needs. Their data systems range from sampling surveys to complete traceability depending on product complexity and the information required to make management decisions.

A common complaint heard from all sectors is that AFM 66-1, Maintenance Management, and T.O. 00-35D-54, USAF Material Deficiency Reporting System, data is inadequate for problem detection or corrective action. This results from the data not being accurate or timely; nor was it intended for that use, e.g., AFM 66-1 data is for maintenance management. Some organizations have augmented these data systems to obtain specific data needed on critical systems and subsystems. When taken in the aggregate, it appears that the AF data systems are generally as good as those observed in industry considering that both must tailor existing systems to their needs. AFSC data use is restrained, however, by the fragmented collection systems used and the absence of a centralized focal point for all data. Thus, no one organization appears to use all the data actually available to it.

The exceptions are when specific data requirements have demanded total tracking and management is willing to fund this additional effort. Two specific cases where AFSC does not appear to take full advantage of the data available are: contractor data and trend analyses are often not provided to the program offices, nor are they always evaluated by the CAOs; CMSEP generates a wealth of valuable information but this information is generally not provided to the program offices unless the condition has resulted in a cost and/or schedule impact. Prior knowledge of contractor trends could permit preventive actions or better planning by the program offices. This lack of information flow tends to be detrimental to a teamwork approach. If the program office has not been kept apprised of potential problems and the CAO's handling of them, then they tend to overreact when advised of the cost and/or schedule impacts or when they uncover the problem themselves. Conversely, when kept properly informed as to CAO actions, the program office's confidence in the CAO is generally better and thus more conducive to mutual problem resolution rather than assigning blame. Likewise, CAO positions with the contractor are often overridden by the program office, e.g., a demand for corrective action or refusal to accept a nonconforming article. These program office decisions may be correct; however, if the CAO is not a party to the decision process or kept apprised of other factors influencing the decision, then animosity and frustration are created.

In the commercial environment, industry makes extensive use of field technical representatives for data feedback. This is particularly true during the preproduction testing, field testing and early deployment stages so that accurate and timely feedback is available for product evaluations, improvements and accelerating of product maturity. AFSC has successfully used contractor technical representatives for this purpose in some instances. However, when the AF does not have contractor personnel perform this vital function, there is a definite deficiency in our normal data system and neither AFSC nor the contractor gets adequate failure data for use in determining timely or necessary corrective actions nor for reliability or quality measurements.

Industry management generally requires quality and reliability reports to be made to them in great detail so that they are able to continually assess their company's and vendor's quality performance and make trade-off decisions based on risk and cost analyses.

Air Force managers are generally interested in hearing about quality only on an exception basis, i.e., whenever there is a quality problem that impacts cost, schedule or performance. Reliability tends to be of a little more interest in that higher headquarters requirements demand reporting this factor, but only with respect to whether the goals have been attained and seldom for program decisions.

An area of quality measurement that was criticized by both industry and government as being deficient was that of automated test and inspection equipment. Many advances are being made in computer controlled manufacturing techniques and technical processes. However, the conformance verification of the products manufactured by these methods is often more time consuming and less sophisticated than their manufacture. Both industry and the government are faced with a cost dilemma in this area. Both appreciate the value to be received in developing automated or improved test and inspection equipment. However, the defense industry has no incentive to fund such research since the average historical inspection costs are normally allowed as a percent of direct manufacturing labor costs on new proposals. Also, the uncertainty of new government business precludes assurance of repayment of such major investments. In addition the government has several problems related to this issue. There is often a lack of awareness of the specific needs or likelihood of achieving the technology needed. There is also a general reluctance to fund research for equipment in light of the competing pressures for RDT&E funds more directly related to mission requirements. Thus, it appears that the government must motivate industry and participate with industry in these development efforts by providing seed money for such programs. In the long run, such capital investments will enhance product quality and improve inspection productivity, thus reducing acquisition and life cycle costs.

D. Education/Training

U.S. industry generally provides work related technical training to their employees. Equipment and system training is also available. Training in management and supervisory disciplines is not as readily available. Career development training is rare. College tuition assistance programs are generally provided for white collar workers. Some companies are reluctant to provide extensive training due to high personnel turnover rates.

All types of training are generally available and required in Japanese industry. New employees generally received extensive training. One year of technical training is common with emphasis on quality assurance. All company employees normally receive some training in the quality discipline regardless of their position or functional assignment. Training in quality is also provided to top managers. Training in Japan is considered to be a normal and necessary part of doing business and a good investment. Life-time employment, common in large Japanese companies, is an incentive to provide training.

Training and training programs in the U.S. military services and agencies range from extensive to almost non-existent. AFSC falls into the latter category. The Defense Contract Administration Service (DCAS) has an extensive training program. In addition to the training that is available from DOD schools (e.g. AMETA), DCAS has two excellent quality assurance training programs. One is an individual certification program whereby quality assurance specialists are certified in one or more commodity areas. Not satisfied with the availability of courses from DOD schools, DCAS has developed an in-house capability to provide 37 courses on-site. Many of these courses were developed by DCAS. Qualified instructors are trained in each regional office and many sub-offices. In FY78 alone, DCAS taught 432 in-house courses and trained 4,741 students. About 78% of all DCAS quality assurance specialists are certified in one or more commodity areas. The second DCAS training program is a formal intern program. This program provides a continual input of well-qualified, motivated, high potential personnel to fill various quality assurance positions as they become vacant. The program is designed to output staff specialists, in-plant specialists, quality engineers and safety specialists. The intern program is three years in length and consists of both classroom and on-the-job training. The program costs about $57,000 per intern which includes salary, travel and moving expenses for the three years. Formal training is mostly provided by AMETA. DCAS inputs about 60 interns a year.

The Army has three quality assurance intern programs: one for quality assurance specialists, one for quality engineers and one for ammunition specialists. The Army's programs are the oldest in DOD. The Army graduates about 60 quality assurance specialists and quality engineers each year. These programs are also three years

in length and consist of classroom and on-the-job rotational training. The specialist and engineering program classroom training is provided by the Army's own school, AMETA. These programs are similar to the DCAS program but tailored to the Army's needs.

The Navy also has a quality intern program. It is for quality engineers only. It, too, is three years in duration and consists of six months of classroom training and two and a half years of on-the-job training at several Navy activities. The Navy program is the newest of all the intern programs. They input about 25 engineers each year. The unique feature of this program is that most of the training effort is accomplished by contractors. NAVMAT developed training outlines tailored to their needs and contracted for course development, course materials and instructors.

AFSC has neither an intern program nor a formal training program. Quality assurance training in AFSC is obtained by requesting training allocations through the AFSC personnel office. Training spaces obtained this way are few and far between. The Hq AFSC Quality Assurance Office has been attempting to establish a quality engineering intern program for over a year. Lack of manpower spaces have frustrated this attempt. As a result there is very little quality assurance training in AFSC.

There is an AFSC intern program in the Contracting and Manufacturing organization known as Copper Cap. These intern spaces are restricted to contracting and manufacturing functions. Although quality assurance in AFSC is generally a part of the Contracting and Manufacturing organizations, no spaces have been allocated to quality assurance interns.

The educational level of workers in quality assurance organizations in industrial firms varies considerably. This variation is generally related to product complexity and criticality. The inspection work force is generally comprised of technicians and mechanics. As complexity and criticality increase, quality engineers, reliability engineers, statisticians and other professionals are added to the quality organization. In U.S. commercial firms manufacturing sophisticated equipment, professionals make up as much as 25% of the quality assurance organization. In some U.S. firms producing defense or space hardware, professionals comprise as much as 40% of the quality assurance work force. These firms are producing some of the most

complex and sophisticated equipment in the world. The AFPRO quality assurance work force is responsible for monitoring the efforts of the contractors' work force and for assuring compliance with contract technical requirements. The AFPRO quality assurance work force includes about 15% professionals. (24% of all AFCMD civilians have college degrees.) Some of the defense contractors felt that the difference in professionalism between the AFPRO work force and their industrial counterparts contributes to the adversary relationship which often exists. They expressed concern that untrained CAO personnel are evaluating the efforts of their highly-skilled and technical work force. Since some CAO personnel are unable to make meaningful findings due to their lack of technical expertise, contractors allege that they sometimes resort to being highly critical but often in insignificant areas. This becomes a source of severe irritation to the contractor's personnel and often results in needless costs. Figure 8 displays the percent of college graduates in the quality assurance work force in the various activities and countries visited.

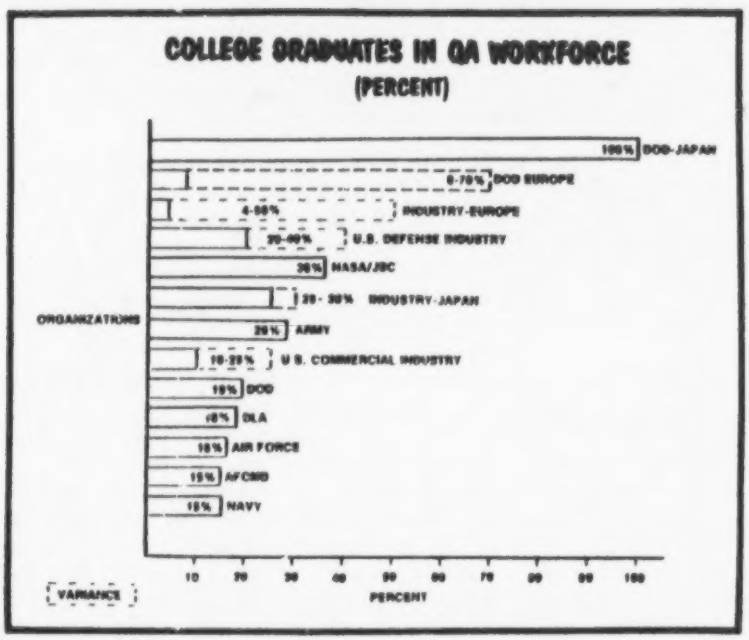

FIGURE 8

E. Contract/Subcontract/Warranty Arrangement

The Quality Horizons study team observed almost as many different "commercial practices" as commercial firms. Many of the different techniques appeared to be simply variations on a theme, however, and there are a number of observations that can be made and conclusions drawn.

First of all, commercial contracting arrangements are mostly firm fixed price and are negotiated before work commences, except for off-the-shelf items. Commercial firms use redeterminable contracts on occasion, where new development or a new product is involved, or even where quantities are uncertain making firm pricing difficult. But incentive arrangements in the commercial environment are the exception, not the rule, both in the United States and in the other countries visited by the Quality Horizons Team.

Commercial firms are able to deal firm fixed price, even on relatively complex items, for many reasons. Some of the most important are competition, vendor specification control, no "changes" clause, commercial pricing techniques, and the market place in general. They base their requirements on current technology, and take advantage of advances in the state-of-the-art only after they are proven; thus technical risk is generally low.

Competition is a strong driver when a vendor is to be chosen for a new program because vendors know that, for the most part, once they have the business, they will keep it. In almost all cases, commercial firms stay with a vendor once the vendor has produced a quality product. When a problem arises, the company and the vendor work together to try to resolve it. This is true throughout the United States and Europe, and is especially true in Japan. When large production quantities are involved, companies will dual or even triple source and maintain continuing competition that way. Even in those cases, vendors perceive the commercial business base as more stable than the Government's. One major consumer goods firm in the U.S. expressed extreme reluctance to change vendors. They stated that their success was first and foremost a result of long term relationships with their suppliers, and emphasized the difficulty and expense of introducing a new vendor to their requirements and business methods.

Specification control by the manufacturer is an important aspect of the commercial business environment. Performance specifications are called out, with the "how to" left to the vendor. The performance requirements are generally well defined and even if it is found that customer demands are different than expected, changes are controlled by the manufacturer. Firms will accept customer specified equipment, but may disclaim any responsibility for that equipment. In the case of consumer goods, customer satisfaction is more important than specification compliance. In other words, is the product suitable for its intended use? One company expressed it this way: DOD is devoted to specification requirements; commercial customers are devoted to results.

Customers have no unilateral right to direct changes in commercial contracts. This means that changes must be negotiated technically, and priced, before they are made. This allows the vendor more stability in his planning and manufacturing, and thus contributes to the ability of vendors to establish firm prices for work that the Government would buy using an incentive arrangement. One U.S. firm told the team they would accept more FFP Government contracts if the "Changes" article were omitted.

Commercial pricing is done more on the basis of market value and competition than cost plus profit. A vendor can include whatever contingencies he feels the traffic will bear, knowing that he can price himself out of the market if the competition provides an equal quality product at a lower price or a better quality product for the same price. The low bidder is not always the winner in the commercial world. Almost all the firms interviewed were willing to pay a higher price to deal with a vendor they were confident would satisfy their requirements, provided they were not gouged. Customer demands for quality are increasing, and industry has perceived that customers will pay more for a quality product.

Past performance ranked high in their criteria for selection of a source. In fact, it is the dominant factor in many cases. A major aircraft manufacturer repeatedly told the team that the only way to achieve quality is to find a way to exclude the marginal performer from future business. Vendor rating systems are a vital part of the overall business strategy of the firms visited. The systems in use by the companies vary in sophistication with the

complexity of equipment and amount of subcontracting involved, but they all serve to exclude the unacceptable vendor, and flag the questionable one so that suitable controls can be imposed. By regulation, the Government must buy from the low bidder unless he can be shown to be non responsive or his technical approach does not fully satisfy the contractual requirement. The burden of proof, in a protest, is on the Government. Experience has shown that it is difficult to sustain a determination of non-responsibility or technical superiority. The low bidder rule is often cited as the reason the Government must stay fully engaged with its contractors. When cost analysis is used in commercial buying, the negotiators are often industrial engineers, or other technical experts knowledgeable about the product, rather than the accountants or financial experts the Government generally uses.

The general perception by a commercial firm is that the market is elastic to quality performance as well as price. They can make a determination of what the market will be and accomplish long range planning accordingly. They maintain they cannot make such determinations regarding the Government market. Government rules about competition and component breakout, along with the annual appropriations process, are cited as the primary reasons.

The teamwork aspect of the commercial company and its suppliers provides an interesting comparison with the relationship between the Government and its suppliers. Before award, the commercial firm is much tougher than the Government would be; using negotiation tools prohibited by our procedures, such as auction techniques. Once a vendor is selected, the relationship becomes a cooperative one, in pursuit of a common goal. The Government negotiating team, on the other hand, has generally cooperative arrangements before award, becoming adversarial after. In most cases, problems exasperate this adversary relationship, so that when the parties most need to be pulling together, they are likely to be engaged in a tug-of-war, where the solution to the problem takes a back seat to placement of the blame. Commercial firms tend to work a problem with industrial engineers and quality specialists, where the Government would use lawyers and accountants. Stable technology (commercial) vs advanced State-of-the-Art technology (Government) is a contributing factor to this situation.

Commercial warranties in the United States, Japan, and Europe tend to be relatively straight-forward and non-complex, applying to materials and workmanship only (not design or processes) for a specified period of operating time or calendar time. Warranty terms are usually established by competition, and firms try to get warranties from vendors consistent with the warranty they offer the consumer. In a number of cases, though, warranty costs are not charged back to the vendor unless they reach some previously established threshold of financial pain for the company. In several instances, this threshold was 3% of cost of sales. In some cases, the warranty is not even specified in the purchase order, but simply an understanding on the part of the vendor as to what level of quality is expected. Clearly in the commercial world both within and outside the United States, it is not the contract guarantee that drives quality, it is company policy and the promise of future business.

Firms that do a high volume of business in a product line generally have historical data to price warranties, but this becomes almost irrelevant at times, because the competition sets the terms of the guarantee. Often, firms decide to assume responsibility for correction of a defect on the basis of the cost of the correction and the predicted loss of customers if they do not make good, even though they have no legal obligation to do so.

The Quality Horizons team also observed a wide variety of contracting techniques, including warranty approaches, in the AFSC Product Divisions and the other Government agencies visited, both U.S. and foreign. All agencies used some firm fixed price and some form of cost reimbursement contracting. Cost-plus-a-percentage-of-cost (prohibited by law in U.S.) is still used to some extent in Germany, while Japan uses cost-reimbursement contracts with a ceiling arrangement which the supplier exceeds at his own risk. Fixed price was the preferred form in all locations. In Europe and Japan, one year warranties are used, covering materials and workmanship. In the U.S., DOD contracts range from CPFF to FFP, with a wide variety of incentive and warranty arrangements.

One incentive technique employed by DOD that is widely accepted as effective is Award Fee. This provision is generally used where there is inadequate information to prepare detailed specifications, where emphasis is subject to change during the life of a contract, or

where an item of special importance to the Government is of only peripheral importance to the contractor. Award Fees are useful where warranties would not be, and they keep the communication channels open between the seller and the customer. At both NASA, Houston, and a DOD contractor in California, an Award Fee allocation to Quality Assurance increased the stature of the QA organization by assuring visibility and emphasis by program and company management to the quality requirements. Thus, their participation was solicited commencing in the early design phase. Both Government and contractor program managers recognized a new emphasis on quality. The Quality Assurance manager of the California firm stated that with several hundred thousand dollars riding on quality he became an important part of the program management team.

The Navy's lease satellite program is the closest emulation of the commercial environment by a Government buying activity encountered. This satellite is to provide secure communications with ground stations for five years. All financing of this program is done by the contractor, with payments beginning when services begin, in orbit, in October 1981. A performance specification is used, and commercial time sharing is permitted. While the Navy will exercise close technical surveillance, design control remains with the contractor.

In all the AFSC Product Divisions, there is increasing emphasis on the use of warranty provisions; such as Reliability Improvement Warranties (RIW), Correction of Deficiencies (COD), and some limited use of standard commercial warranties. Unfortunately, use of a RIW or other guarantee has not generally resulted in reduced in-plant surveillance, or changes in contract quality management system requirements. Thus, the Government may be conducting needless contractor monitoring and paying additional costs. Whether the increasing use of these provisions has improved quality or whether they are cost effective is hard to judge at this point. It is generally agreed that RIW provisions are serving to improve the feedback of information to the manufacturer to assist in the correction process. Whether an effective warranty can be negotiated depends in large measure on the competitive nature of the purchase. The Government is generally able to include warranties in competitive contracts. In sole source situations, the contractor tries to establish a price that is prohibitive, or so emasculate the provision as to render it worthless.

In summary, there are more than enough tools available to the contract negotiator, but none of them are foolproof. There is no substitute for intelligent assessment of the government's objectives and selection of a business strategy consistent therewith. Ideally, the best contract would be referred to the least and the best warranty would never be referred to at all. Specific strategies for an acquisition should be tailored to the program and the contractor, keeping in mind that no form of assurance is free, and that the objective should be to get the most for the taxpayers' money.

F. Motivation

One could postulate a "hierarchy of needs" for the American worker, and at its base would be job continuation. A majority of the United States firms visited rely primarily on the promise of future work to motivate their work force. Many companies in the United States have such high worker turnover, or such heterogeneity in the work force, or both, that training programs or other motivational programs have been futile. Thus, job continuation as a motivator is augmented only by negative motivation (discipline).

Where the labor force is more stable, there are some motivation programs in operation in the United States. QC Circles, upward mobility programs, and other, generally ad hoc, programs are used to encourage quality and productivity. Employee recognition programs tend to be noncompetitive; that is, everyone can win, and they offer nominal rewards like coffee cups or T-shirts. The programs are considered effective, but need constant rejuvenation. The study team heard mixed reactions to QC Circles in the United States; some firms are using this approach with some success, others without any success, and still others say the notion is only a gimmick and will not work in this country because of the cultural differences and the heterogeneous work force.

One large firm told the team that their system of promotion sorted out the self-motivated people so well that there was no need for any other program of job enrichment. Other firms told the team that the professional workers, e.g., engineers were self-motivated, and that management emphasis improved quality more than any other factor. The design engineer will resolve cost and quality problems if they are presented as requirements equal to other performance considerations. Top management attitude is the key to improvement in this area.

In Japan, Zero Defects Programs are still effective. However, the main motivator is QC Circles, which originated in Japan about the same time that Zero Defects got its origin in the United States. Zero Defects and QC Circles both emphasize elimination of defects. Zero Defects, however, centers on the individual while QC Circles center on groups of workers. QC Circles are a form of participatory management in which workers, usually 6 - 10, form a group which periodically meets to review their responsibilities, problems encountered and to suggest ways to improve work performance. The suggestions may cover any area which will improve productivity, quality or the work environment. One company reported savings of approximately $250 million every 6 months as a result of this suggestion program. High worker morale is achieved because the workers accept their responsibility for product quality and are proud of their achievements. The Japanese workers are further motivated by a bonus system. The workers may earn bonuses of 40% to 60% of their salary depending upon their individual and group performance and the company profits. High levels of training, low turnover rates and the paternalistic attitude of management also contribute to high worker morale.

In Europe, the team observed the beginning of QC Circles, but the primary motivator seemed to be upward mobility programs based on employee performance. They also have recognition programs using certificates and awards. Representatives of several European firms talked about the de-motivating aspects of overly detailed procedures and also of the difficulty in getting the worker to take responsibility for his work when an inspector is looking over his shoulder each step of the way. Bonus payments in Europe, like in Japan, are common. Traditional craftsmanship is also a factor in Europe with the satisfaction of having done a good job the primary motivator.

The issue of motivation is a difficult one. Programs of all types seem to work, for a while, but experience would indicate that they are difficult to sustain. The programs that have endured are "tradition" in Europe and QC Circles in Japan, but they still require sustained management emphasis. Where management was slow to respond to worker needs, failed to adequately consider worker comments or failed to continue support of the motivation programs, the programs

ultimately failed. While no panacea was observed, it was generally found that large organizations need simple and sincere motivation programs to foster pride in workmanship and a sense of belonging. While these programs are not universally successful, within each company some form of motivation did seem to contribute to employee concern for the company's image as manufacturer of quality products.

G. Field Services

The field service support provided by industrial firms is dependent on the customer (consumer, industry or government), the complexity of the product, and the warranty provided. Products sold to consumers are generally serviced by sales and service centers or returned to the factory. The primary concerns of the producer are to minimize warranty expenditures, to maintain user satisfaction and to remain competitive. With products sold or leased to other industrial firms, the producing firm normally does not get paid until the unit is proven acceptable to the buyer. These products are generally more complex than consumer products. Field service costs for commercial items are included in the purchase price while field services for military systems are separately priced. Field services are generally not used on military systems unless no other alternative appears to exist for a specific problem such as untrained personnel.

Field service in the companies visited was located in various organizations. These included engineering, manufacturing, quality and marketing. In some firms, the field service organizations were separate profit centers if they provided field services for all corporate products.

Some of the basic functions performed by field service organizations are technical assistance, analysis of field complaints, training, and accurate and timely feedback of failure data. The field service representative may perform or advise the user in performing maintenance on the system. In addition, since the field service representative generally has a direct line of communication to the manufacturer, the response time necessary to provide technical assistance for resolution of maintenance problems or customer complaints is greatly reduced. A field service representative may also provide technical assistance through a purely advisory role.

Accurate and timely data feedback and analysis of field complaints provide the manufacturer with the information necessary to improve customer satisfaction and determine trends in performance and/or reliability. A universal complaint that the study team heard was that data available to the contractor on system performance of military systems is not timely, accurate or complete. In most non-military situations the primary measure of quality is the cumulative in-service reliability of all field units of a particular product. Complaint analysis and data feedback provides the manufacturer with the data necessary to mature the system.

The policies for providing field services are varied and dependent on several factors. Of prime concern is the customer's requirements. Field service provided to the consumer is generally limited to the sales and service centers which provide warranty as well as post warranty maintenance or replacement. If the customer is another industrial firm, field services provided are dependent on the warranty specified by the terms and conditions of the contract and the pressures of competition. In some European countries, field service is often not a distinct entity because the national laws require all products to be warranted. Therefore, the law levies on the producer the repair responsibility. However, some firms have extensive field service organizations because they do not receive final payment until their product is installed and operating as specified. It was noted that the military, in the countries visited, separately contracted for maintenance and field support except for products that were covered by warranties. Where items were covered by warranties, the product was returned to the factory for repair. In Germany, if the item was commercial or a commercial derivative, the item could be taken to the commercial sales and service outlet for repair. Where field service was required in Germany, it was separately priced but often provided at cost.

The warranty duration was also a driving factor in companies' decisions to provide field services. In product lines which had long service lives such as telephone systems purchased by European companies, there were extended warranties. In the United States, the manufacturers of telephone equipment assign representatives to the operating companies who in turn lease the equipment to the customers. Whether purchased or leased, equipment must meet specified reliability requirements; otherwise,

excess maintenance costs are passed back to the manufacturer. Field service personnel are invaluable in identifying and helping resolve problems and minimizing total systems costs.

The commercial portion of the aerospace industry in the United States provides field service support for a specified period of time after delivery of the last aircraft of a certain model or as long as there are a certain number of that aircraft in service. Several factors favor the use of field service personnel on the commercial side of the aerospace industry. The first is competition. Even though an airline may have a considerable investment in one manufacturer's equipment, they have the option of purchasing similar equipment from another manufacturer. Aerospace companies must provide service to insure a high degree of customer satisfaction. The second factor is that the aerospace companies have design flexibility and responsibility. The aerospace firms can, and must by FAA direction, make design changes if a safety problem is discovered. To a large extent they can also change the design to increase product reliability or performance or decrease manufacturing costs without prior customer approval. When changes other than those directed by the FAA are made, the airlines have the option of incorporating the changes in the aircraft already in service and are generally provided modification kits at a low cost. Field service representatives provide much of the data necessary to make design changes. A third factor is the method of contracting. Commercial contracts are relatively short and specify the what-when-where and how the customer is purchasing. This includes delivery dates, warranties, performance and special equipment that the customer wants. All services which will be provided both before and after delivery are included in a single price. Usually when the airline performs maintenance covered by warranties, the producing firm is charged for all or part of the expense involved. Field services in this case verify that the work was in fact warranty work. The final factor is technical support during early organic maintenance. The airlines, much like the Air Force, start providing maintenance as soon as the system is in operation. Field service representatives assist in the maintenance of the aircraft and training of personnel.

H. Government Involvement/Surveillance

The study team evaluated the FAA involvement in the commercial aircraft industry. In this area the FAA is regulatory in nature since the Government (FAA) is neither the buyer nor the user of the equipment. The FAA certifies the aircraft (airworthiness) and the manufacturer's production plan, methods and techniques (Production). The Airworthiness Certificate is basically awarded as the result of design analysis and testing in accordance with the applicable Federal Air Regulations (FARs). The Production Certificate is based on the actual manufacturing of the article.

The FAA makes extensive use of Designated Manufacturer Inspection Representatives (DMIRs) to perform surveillance of the manufacturing processes. They are company employees who are intimately knowledgeable of the manufacturer's processes and procedures as well as the FAR requirements. DMIRs are selected by the company and approved by the FAA's Principle Inspector for the facility. They actually wear an FAA hat while on the company's payroll in assuring that the company procedures, inspections, etc., are in accordance with the FAA requirements and are adequately performed. The FAA's Principle Inspector for the facility monitors the performance of the company's DMIRs. Those FAA and company representatives interviewed felt that DMIRs have no conflict of interest. They indicated that DMIRs would not hesitate to reject a nonconformance regardless of the impact it might have on the company's delivery schedule or cost. The reason given was that DMIRs consider their positions very prestigious and thus are self-motivated to maintain their status. They do not receive extra pay for this position; however, they are usually senior employees and the position provides additional job security.

The FAA assigns a Principle Inspector and occasionally additional representatives to a manufacturing facility. The FAA Principle Inspector is responsible for conducting surveillance to assure that the manufacturer remains in compliance with FAA requirements. Primary functions include:

1. Approval/evaluation of QC data.

2. Evaluation of inspection/quality assurance of manufacturing and special processes.

3. Conducting compliance/conformity inspections of products.

4. Training, supervising and monitoring the DMIR activities.

5. Investigation of in-service difficulties.

6. Investigation of regulatory violations.

7. Assurance that effective corrective action is taken for all unsatisfactory conditions.

Periodically, the FAA (regulatory) conducts a Quality Assurance System Analysis Review (QASAR). A team of highly trained FAA personnel conduct an in-depth review of the manufacturer's conformance to the FAA approved plans and procedures upon which the Production Certificate was granted. The contractor's incentive to maintain compliance with the approved plans and procedures is the threat of losing the Production Certificate which is essential to certify the aircraft as airworthy. An additional impetus that encourages contractors to comply with FAA regulations is the threat of civil penalties such as large fines or imprisonment and the notoriety such actions receive through the media.

The FAA in the role of customer (FAA uses the equipment) performs much like that of a program office during system acquisition. The FAA first reviews the contractor's manufacturing and quality programs for acceptability. If acceptable, the contractor's Quality Plan is certified; then, any changes desired by the contractor must be submitted to the FAA for approval. Subsequent to Quality Plan approval, the FAA maintains minimal representation within the plant. Many FAA contracts require the installation and checkout of the system before payment. This provides additional assurance that the system will function satisfactorily before relieving the contractor of his responsibility.

The U.S. Army (DARCOM) involves the quality assurance organization in each phase of an acquisition life cycle: conceptual, validation, full-scale development, production and deployment. The Army designs much of the equipment they purchase. Most of their equipment is manufactured by contractors under the cognizance of DCAS. Extensive use is made of the Letter of Instruction (LOI) by the Army. Through the LOI the procuring offices can direct the activities of the in-plant

government agency. The Joint Service Regulation for Procurement Quality Assurance Programs (DLAM 8200.1) is used at those contractor locations under cognizance of the Army as well as those under DCAS.

DCAS has used the concept contained in DLAM 8200.1 since it was published in 1962 and recently developed the Contractor Assessment Program (CAP) as Appendix D of DLAM 8200.1. This program is currently being tested at carefully selected locations. The agreement signed by the contractor (DLAM 8200.1, Appendix D, Fig 6) contains the following elements that are not required by MIL-Q-9858A: (1) obtain government concurrence prior to changing identified key elements of the company's quality control program; (2) audit product inspection after normal company inspection is complete; (3) evaluate the company's quality procedures through periodic compliance reviews; and (4) report the results of monitoring and reviewing actions to the government.

CAP requires the contractor to accomplish most of the activities that were previously accomplished by the government QAR. This permits the contractor's workforce to maintain a more consistent and efficient flow of work, since they do not have to wait for DCAS inspections (except for established mandatories) before moving parts or materials from one work station to the next. More of the DCAS QAR's effort is spent on assuring that the contractor's quality assurance system is properly controlling the manufacturing processes, that the contractor's system is detecting nonconformances preventing them from being built into products or going into inventory and assuring that corrective action is taken to prevent recurrences. This is accomplished by a more flexible inspection schedule with a more disciplined reliance upon statistical sampling and lot acceptance techniques. This not only permits the QARs to evaluate more areas of a contractor's operations, but it also allows them to concentrate their efforts in areas where problems have been detected. Once these problems are resolved, they then concentrate on other areas where sampling inspections, reviews of contractor's records or other monitoring have indicated potential problems.

Those contractor and DCAS representatives interviewed felt that the CAP system resulted in a much more effective and efficient utilization of scarce government resources. In most cases moderate reductions in the number of in-plant government inspectors were achieved. It also improved the working relationship

between the DCAS and contractor in that the emphasis was on the contractor's system and data, not on trivial concerns which often create animosity. The contractor is truly considered responsible for the quality of his product. Contractors maintain that their management is motivated to make sure the program works because they are proud their company was selected for CAP. They also indicated that their employees are motivated to do a better job. While data is not yet available to conclusively evaluate the CAP impact on product quality, contractors maintain that it has not degraded product quality and in some cases has enhanced it. The DCAS organizations visited support continuation of the program as a valid tool to place more quality responsibility on contractors without abnormally increasing government quality risks or reducing confidence levels. The very limited CAP data shown to the study team did not reflect any product quality degradation due to withdrawal of in-plant government inspectors.

The Navy Plant Representative Offices (NAVPROs) previously conducted the in-plant quality assurance program specified in DLAM 8200.1. Currently, the NAVPROs are implementing a separate Quality Assessment Program (NAVPRO QA Procedure 4.3.4). This program establishes product verification teams responsible for discrete manufacturing areas. Their verification effort is accomplished less frequently than required by DLAM 8200.1, but in more depth. The results of each verification are formally presented to the contractor's top management for action. This program differs from the DCAS CAP in that the NAVPRO does more verification of product conformance through actual inspections.

Government involvement at contractor plants under Air Force cognizance does not vary greatly from that of other government CAS organizations. AFCMD has developed and implemented the Contractor Management System Evaluation Program (CMSEP) which is designed to accomplish evaluations using the management systems approach. The baseline for this program is the contractor top management official's assignment of responsibilities to his functional directors. Verification of contractor compliance to contract requirements is assigned to the various AFPRO functional divisions according to this baseline. Each contractual requirement is checked by specific condition questions (management system indicators) which the AFPRO personnel use to determine the

existence and adequacy of the contractor's written instructions. Subsequently, the AFPRO personnel verify that the contractor's employees are complying with the written instructions through procedures verification monitoring and product inspection verification. The quality assurance function uses this approach for verification of both management procedures and work instruction procedures. The verification of compliance to work instructions is a continuous evaluation while the verification of compliance to management procedures is a scheduled activity.

In Japan and Europe, government involvement for defense work is very similar to that in the United States. Other sections of this report provide data concerning their efforts and manpower allocations. Generally, it was observed that in Japan and Europe the work force of government quality assurance was one representative to ten contractor quality representatives; within AFCMD the ratio is closer to one government QAR to 20 contractor quality representatives.

I. Summary

Many managers engaged in the military acquisition process on both the government and contractor sides give lip service to quality and the "ilities". Managers generally recognize the importance of these efforts and want front end attention to defect prevention, reliability and maintainability, but only to the extent that noncompeting funds are available to support their related costs. Detracting from the level of importance given to the "ilities" is a general lack of appreciation on management's part as to the trade-off analyses that are possible in these specialities. Thus, the manager often feels confronted with "all or nothing" choices as to "ility" requirements. Often neither of these choices would have resulted from a trade-off study which included the costs of product failures caused by the omission of these requirements. To establish tailored "ility" requirements that are consistent with cost, schedule and performance constraints requires sufficient manning and skill levels. Unfortunately, these levels are generally not available. Thus, the program manager may have inadequate information upon which to decide the apportionment of limited funds for competing requirements. Another factor contributing to the early de-emphasis of the "ilities" is that the pay-off from these programs is often not realized by the manager having this decision

responsibility. The impacts of not performing these tasks are realized much later by the manager's successor or by the operational and support organizations.

In addition, many military and DOD contractor acquisition managers do not take the time and effort to fully understand the tools, techniques and benefits of the assurance engineering disciplines and some of the managers are also reluctant to properly man, fund or accept the recommendations of these specialists. Rational management decisions predicated on objective evidence of cost payoffs is emphasized. However, it is often easier to measure the costs of failure, than to cost success in these disciplines. Managers must recognize that unless properly manned and funded, these functions cannot effectively or efficiently support the acquisition objectives nor can adequate information be provided so that well informed management decisions can be made.

V. NEW APPROACHES TO AFSC PRODUCT ASSURANCE

A. Introduction

The Quality Horizons Study Team's recommendations presented in this Section are summarized in an Action Plan. The Action Plan contained in Appendix I has been prepared and organized to facilitate review, implementation and tracking of approved recommendations. The Action Plan contains a cross reference to this section of the report for additional information as may be required.

This section is grouped into the following eight categories in order to provide for a logical and sequential development of the new approach to product assurance:

Policy

Organization

Manning

Education/Training

Contract/Subcontract/Warranty Arrangement

Motivation

Government Involvement/Surveillance

Life Cycle Product Assurance

The study team has observed that there is a common thread that permeates all successful programs, both commercial and military. That theme is that there must be a disciplined approach to planning, utilizing the assurance disciplines. Design guidelines must be developed that are consistent with cost, schedule and performance requirements. Then throughout design, development, and production phases; analyses, controls, and conformance verification must be implemented to assure that the product will perform as required in the intended environment. Quality considerations must be an inherent part of the product design, development and test.

Programs that have been most successful have utilized these concepts extensively with significant emphasis on the front end design efforts that will eliminate or minimize product assurance risks. In each case these efforts began with and were continually demanded by top management. Management established specific program requirements and then assured that integrated trade-off analyses were conducted in each area to develop a program plan that would accomplish these objectives within cost and schedule constraints. Program management considered not only the inputs of each program element but assured that each element's input represented a coordinated and integrated position. Program decisions were based on complete information. The recommendations that follow are designed to achieve these same results within AFSC and meet the Quality Horizon Study objectives set forth in Volume II, Section 4.

In order to fully recognize the scope of the concept presented in this section, it is imperative that the definition of PRODUCT ASSURANCE be understood. The application of these concepts to the traditional view of quality as only a conformance discipline will result in misunderstandings. A new phrase rather than redefinition of an existing term, was specifically selected to call attention to the fact that a new approach is being recommended for use in AFSC.

> *PRODUCT ASSURANCE is the application of interdisciplinary skills to accomplish the preventive and conformance activities necessary to assure: that requirements are properly specified, that the design will achieve these requirements and that the ultimate product and/or services will perform their intended functions in the operational environment for the period specified.*

Many skills, disciplines and sciences contribute to or have responsibility for product assurance, not just the quality function. Quality, reliability, maintainability, etc., must be designed and manufactured into the product not just measured through inspection or tested in, although both inspection and test are essential for verifying conformance. The product assurance concept can, given the opportunity, integrate these complimentary actions currently fragmented within AFSC.

B. Policy

The objective of AFSC's research, development and acquisition programs is to provide the using commands with products and services that fully satisfy mission requirements and user expectations. To achieve this objective, a combined effort is necessary to assure that proper technical requirements are contractually specified and that the products conform to these specified requirements.

Top management attention by AFSC and industry is essential to attain this goal. General Slay's efforts, including the direction of this study effort are well known to AFSC and industry. His direction to implement recommendations of this study will further support management's resolve to assure better quality products to users. Such management actions will be essential in order to shift AFSC's emphasis from problem detection and correction to one of prevention as described under the product assurance concept.

Although government/industry teamwork and excellent management have resulted in some highly successful programs, these effective management initiatives must be institutionalized and used on a broader basis. Current guidance in DOD Directives, AF and AFSC Regulations in the individual functional disciplines (e.g. MIL-Q-9858A, MIL-STD-1543, AFSC 74-1, etc.) is generally adequate. However, since the implementation of this guidance is often incomplete or not effective, AFSC's and industry's top management must assure that the proper emphasis is given to product assurance. To attain this objective an AFSC Regulation that integrates the tasks and functions defined in the current regulations, standards, etc. must be developed. This Product Assurance Regulation will not only provide for more effective use of scarce resources by preventing duplication of efforts, but its orchestrated approach will assure a program orientation that minimizes program risks and achieves the required performance at the lowest possible cost. It will incorporate a system of checks and balances to assure that each organizational level fulfills assigned responsibilities. One such verification requirement would be to justify to program management the inclusion (or elimination) of each specific product assurance task or function required by this regulation. Such management emphasis will elevate these performance requirements to a level of concern equal to cost, schedule and other performance considerations.

Many managers do not recognize that the assurance disciplines have evolved from "black arts" to engineering sciences with proven tools and techniques for their proper application. These functions are no longer fragmented efforts but complement one another. Their analyses, applications and evaluations rely upon the same basic data, such as, failure mode analyses. Yet, many responsible and competent individuals within these functional disciplines have not been exposed to the experiences of other programs or the tools and techniques effectively or ineffectively used by them. Effective lessons-learned and training programs must be undertaken to provide AFSC personnel with the opportunity to perform to their fullest capabilities.

Expertise and experience acquired on one program must be transferred to all AFSC organizations. One valuable method of achieving this objective is through a formalized lessons-learned program which will reinforce AFSC's corporate memory. The method recommended to accomplish this would be to develop AFSC Handbooks for each functional discipline. Each handbook would contain guidelines for applying the tools and techniques of the specific discipline and how it interacts with other assurance disciplines. The guidelines should include a brief description of the tool or technique, how it is applied for various products and contracting methods, the benefits it provides, approximate costs associated with its specific applications and the risks of not performing these tasks. An OPR for each discipline must be established who will be the focal point for lessons-learned by all organizations. The OPR will be responsible for assuring the incorporation and distribution of all changes. Several pamphlets, handbooks, product division standards and office instructions have been developed with much of this information. However, these documents have not been distributed to other AFSC organizations nor do they always incorporate lessons-learned from other organizations.

To maintain management emphasis on product assurance, the visibility and knowledge of this element of a program's performance must be of prime concern. To do this, AFSCR 800-23 should be revised to require each Program Manager and Air Force Plant Representative or CAO Chief (DCAS/NAVPRO) to report on product assurance successes and problems at each Command Assessment Review and Program Assessment Review. Additionally, program managers should stress to their contractors the

importance of including product assurance status, problems and concerns in program technical and management reviews. Reporting of product assurance requirements is already accomplished in many forms such as data item description submittals and functional management reviews, but program management frequently does not receive even a summary of these reports. Contractors and project officers should be required to brief program management on these items.

The suggested new approach to AFSC product assurance is necessary to provide the methodology and assure the consistent and disciplined application of these policies by management.

C. Organization

The recent trend in DOD, as well as industry has been to combine some, or most of the assurance disciplines into one organization, reporting to top management. The Army (DARCOM) was the first service to do this, followed by the Navy (NAVMAT), and the Air Force (AFLC). There is no quantitative data to prove that these organizational changes have resulted in improved product quality. It would be difficult to accumulate such data for any organizational change, but increased attention to the assurance disciplines was observed in the combined organizations. The Quality Horizons' Study Team believes that a similar organization change in AFSC would be required to maintain and improve quality levels during the current trend of diminishing resources.

The recommended organizational change will eliminate the current fragmentation which exists in the assurance disciplines by combining the primary functions which impact the quality, reliability, safety, etc., of the product. This will facilitate communications between Hq AFSC and all subordinate levels. In addition, this organization will promote consistent application of the tools and techniques available to the product assurance disciplines, optimize implementation of lessons learned and use of manpower resources. Even more significant is the fact that the proposed organization will raise the level of influence that the assurance disciplines have on program decisions in all phases.

The critical mass of personnel and centralized focal point for product assurance attained by this new organization will enhance their overall program orientation. The currently fragmented structure forces a myopic

view ("cultist" orientation) that often does not consider the overall program objectives or constraints. The integrated positions developed through this new organization will permit more informed program management decisions resulting in delivery of a quality product that meets user needs at the lowest possible cost.

The organization in AFSC which will be most successful in improving product quality is one which combines the assurance functions specified below. This organization should be titled Product Assurance and report to the Commander at Hq AFSC and subordinate units. While it is true that the individuals assigned to an organization have a strong influence on its success or failure, the proper organization structure will enhance the probability of mission success.

The new product assurance organization will be responsible for the following functional disciplines which are currently being accomplished by various organizations in AFSC:

1. Quality Assurance
2. Reliability
3. Maintainability
4. System Design Safety
5. Manufacturing (except at AFCMD)
6. Standardization
7. Corrosion Control

Included in each of the above areas would be all of the tools, techniques and subfunctions which support these areas such as: Man-Tech Program, Q-Tech Program, nondestructive evaluation program, quality assurance engineering, product assurance testing, metrology, software quality assurance, vendor quality assurance and producibility, derating, failure mode analysis, parts control, etc.

The main advantages to the product assurance organization are:

1. It enhances front end involvement during design and development phases.

2. It combines similar functions which are interrelated and are currently fragmented in different organizations in AFSC.

3. It provides clear and direct lines of communication by establishing organizational symmetry.

4. It reduces duplication of efforts, multiple interpretations, and conflicting direction from different activities.

5. It increases productivity and manning flexibility by combining personnel with related disciplines and overlapping capabilities. It provides for a critical mass of personnel at those organizations where manning is not adequate to support an office in each of the disciplines.

6. It overcomes the tendency for different functional disciplines to compete on an individual basis for funding and manning resources and develops a broader perspective toward total program needs.

7. It provides for continuing visibility and attention to product assurance by top management by requiring that the organization report directly to the Commander.

8. It gives product assurance an independent and stronger voice in management and program decisions so that product assurance will not be subordinated to cost, schedule or other performance requirements.

9. It improves career progression and the ability to attract and maintain highly competent people.

10. It demonstrates to contractors that AFSC thinks product assurance is as important as other performance parameters.

The primary disadvantage is that it will increase the span of control for the Commander, Hq AFSC and Product Division Commanders. On the other hand, the span of control at AFCMD will be reduced and it has the potential for reduction in program offices.

Figure 9 shows the proposed organization with its direct line of communication.

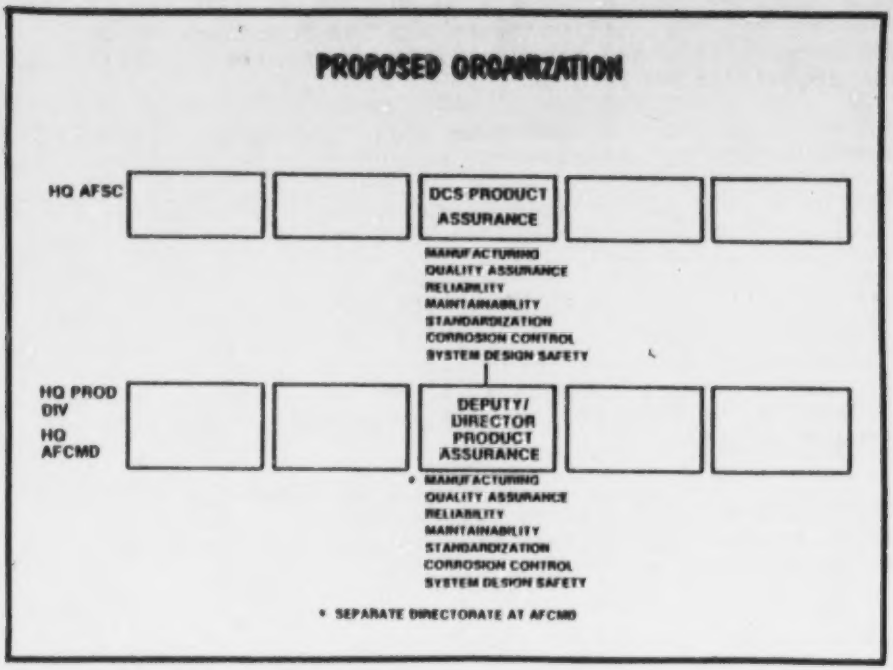

FIGURE 9

If the above organization is not considered practical at this time, an alternative would be to reorganize in two phases. Phase one should be to reorganize and combine product assurance disciplines at HQ AFSC only. This would emphasize to AFSC field organizations the need to enhance product quality through a teamwork approach of product assurance and assure greater attention to these disciplines early in the design and development efforts. Over a period of time, an evaluation should be accomplished by HQ AFSC to determine if the early involvement product assurance concept is being effectively accomplished at the field organizations. If not, phase two should be implemented, i.e., the reorganization and combining of product assurance disciplines at all AFSC field organizations. This would institutionalize the product assurance concept and enhance its accomplishment at the Product Divisions and AFCMD.

Action should also be taken to transfer the expertise and program knowledge derived from the initial acquisition activities by the product divisions and

program offices to the contract administration offices at the contractor's plants. An effective way to accomplish this transfer of corporate knowledge is through strong communication channels between the product divisions, program offices and contract administration offices. Since a large number of AFSC contracts are administered by CAO's outside AFSC (DCASs and NAVPROs), communication with these organizations must also be strengthened. The number of AFSC contracts under DCAS administration warrants the establishment of a DLA liasion office at each Product Division to facilitate communications. This will enhance the ability of program offices to relate concerns and problems and attain confidence in the contractor's performance as reported by the CAOs. This will permit DLA to re-allocate their resources accordingly and will strengthen the working relationships between these team members, enhancing overall effectiveness.

D. Manning

It was generally observed, in those organizations where assurance disciplines were combined, that the quality assurance manning was distributed more heavily toward the front end of the product life cycle than is the case currently in AFSC. Thus, without changing the basic assumption that no additional manpower resources will be requested, (except for the possibility of an intern program which is described in V.E.), re-allocation of existing manpower is recommended. All of the manpower currently performing the assurance missions listed under Section V.C. - Organization, would form the pool for this ultimate re-allocation.

Under the product assurance concept, there will be a much greater involvement by product assurance personnel in the earlier phases of the acquisition cycle. This early emphasis on prevention will provide a greater return on existing manpower resources and investment thus allowing for the re-allocation of critical manpower within the product assurance community. The objective should be to assign current resources to those product assurance organizations where they can provide maximum benefits. Currently, there are 56 full time quality assurance personnel in AFSC program offices and product division staffs and 1,184 quality assurance personnel in AFCMD. Thus, approximately 5% of the AFSC quality assurance work force is located in the four AFSC Product Divisions.

The first step necessary to man the new organization should be to identify those resources currently performing the product assurance functions in Hq AFSC, AFCMD, ADTC, ASD, ESD and SAMSO and transfer these resources to the product assurance organization in each of these activities.

It may eventually be necessary to strengthen the manning levels and ability for AFSC personnel to become more involved in early design and development efforts. This should be done by the re-allocation of personnel and vacant positions to the systems program offices and AFCMD activities that can best influence design and development. While an increase in product assurance manning within the Product Divisions is anticipated, an independent study team under Hq AFSC leadership should be formed to determine the most effective allocation of product assurance resources and skill levels within AFSC. The team composition should include representatives from Hq AFSC, Product Divisions and AFCMD, and work in concert with General Slay's direction for a Workload/Manpower Baselining Study (4 Apr 1979). When the study is completed, a plan should be developed to accomplish the re-allocation.

There should be no reductions-in-force or other adverse personnel actions. The initial transfer of personnel from the AFCMD to the Product Divisions would be on a volunteer and selection basis. Subsequent transfer of spaces would occur as spaces become vacant through attrition. Not all vacated spaces should be transferred, but this should be done on a planned schedule until the predetermined re-allocation is complete.

In addition to the realignment of product assurance resources, there should be a concurrent upgrading in the professionalism of the entire work force. Emphasis should be placed on college graduates in the assurance sciences with the prerequisite individual capabilities. Goals should be established within AFPROs to increase the number of appropriate college graduates in product assurance using as a guideline the percent of college graduates in the comparable contractor's work force. Needs of the organization and ability to recruit college graduates should be considered in establishing this goal.

When specific skills are not available within AFSC, a decision must be made to retrain existing resources or contract out for these specialized

skills. AFSC should establish a Command Policy to support contracting-out where necessary.

E. Education/Training

The new AFSC product assurance approach will require significant emphasis on education and training to assure that the work force remains current in the techniques available to the product assurance disciplines. In comparing training available within AFSC to that available to the Army, Navy and DCAS, it was obvious that AFSC lags far behind. The Army, Navy and DCAS all have well established intern programs which concentrate on quality assurance and the related disciplines. AFSC has virtually no formal training programs and does not have a quality or product assurance intern program. U.S. industry does not normally have formal quality assurance training; rather, they concentrate on technical training. However, a good appreciation for quality and/or product assurance will be a natural outgrowth of a well developed technical training program. In Japan, there is extensive initial technical training followed by continuous training in quality assurance. In Europe, the emphasis is on technical training; however, special training in quality assurance is available and regularly used.

The percentage of college graduates in the AFSC quality assurance work force was one of the lowest observed in all locations visited. This lower level of education sometimes hampers the communication flow between AFSC quality assurance personnel and their industrial counterparts.

Over the past few years, the Japanese have raised their product quality level to one of the highest in the world. A major reason for this is the fact that managers, including top managers, receive a substantial amount of training in quality assurance.

The Japanese made us keenly aware of the fact that all levels of management must have a strong appreciation for the benefits to be gained from a product assurance program and they must continuously support the program if the full value of the benefits is to be derived. To achieve this goal, our top management courses such as the senior service schools, Defense Systems Management College, and the System Program Management course should be modified to devote an appropriate amount of time to the role of product assurance

rather than the token recognition currently given. The intent would be to instill in program directors and other top managers a sense of appreciation for the disciplines, when the approaches are best used, and the benefits from effective application of the assurance disciplines. In addition, current AFSC top managers and program directors must be made aware of the benefits they will receive from the new product assurance approach. This should be accomplished by a short, intensive, on-site program presented by an authority in the product assurance field. The investment in these training programs will be returned manyfold in improved product quality and reliability.

A concerted effort by AFSC must be made to raise the educational levels of quality assurance resources, especially in the AFPROs. This will bring the AFSC in-plant educational levels more in-line with their counterparts in the plants serviced by the AFPROs. Some adjustment in grade levels may be necessary to hire and retain the quality individual desired. However, the improvement in communications and problem solving ability would more than justify a slight increase in grade levels.

In line with raising top management appreciation for product assurance and the educational levels of the quality assurance personnel, AFSC must implement a formalized training program to upgrade the skills and capabilities of the product assurance workforce. The program must be centrally managed, adequately funded and supported by management. The resulting systematic approach will assure that AFSC personnel keep pace with industry in their areas of responsibility. The existing skill levels must be surveyed so that the need for development of specific courses for the AFSC-wide training program can be prioritized.

Developments resulting from the new AFSC Quality Technology Program (Q-TECH) may require new courses to be formulated and incorporated in the AFSC product assurance training program to keep the personnel up to date.

Another significant area which needs to be addressed is the establishment of a Product Assurance Intern Program. This program would provide a source of trained, capable and motivated people to fill the vacancies created by retirements or reassignments.

The intern program would produce graduates who understand product assurance from an AFSC perspective. They would be able to perform effectively in Hq AFSC or any of the AFSC divisions. The main theme of the program would be to develop individuals with the technical abilities necessary to perform effectively in journeyman level positions, yet who were also sensitized to program and business management. The graduates of the intern program would form the core of our future top product assurance managers.

The intern program should be centrally managed at Hq AFSC and supported by a distinct budget so as not to be diluted by other requirements. The training should be three years in duration consisting of formal classroom training, training at several AFSC organizations and some on-the-job training in contractor or AFPRO product assurance organizations. The number of interns should be based upon a percentage of the expected attrition rate for product assurance personnel. The program could support a minimum of 25 interns per year or approximately 75 interns when the program is in its third year of operation. It is reasonable to assume that approximately 25-50% of the vacancies occurring through normal attrition during any one year of the approximately 1950 product assurance personnel could be filled by the highly qualified graduate interns. It is necessary that AFSC provide 75 manpower authorizations to support this program. The use of overage positions would be acceptable.

AFSC should also explore the possibility of establishing an AFIT Education With Industry (EWI) Program for product assurance. This program should be made available to military and civilian personnel alike. EWI programs in other functional disciplines have proven to be beneficial.

Prior to developing the individual courses AFSC should evaluate the training courses and capabilities within DOD to determine what AFSC needs cannot be satisfied. If the capability does not exist within DOD, AFSC should develop or contract for the development of the courses. In those cases where there is a limited requirement for certain courses, AFSC should consider contracting with a private institution.

The education and training programs described above are the most pressing needs in upgrading the skills of AFSC personnel involved in product assurance. These programs will also provide the basis for a career development program for product assurance employees.

The Quality Assurance Office at Hq AFSC has begun this effort for quality assurance personnel. However, this effort must be continued and expanded to include the entire product assurance organization.

F. Contract/Subcontract/Warranty Arrangement

One of the major Quality Horizons' study objectives was to tailor and utilize commercial contracting practices to enhance product quality and support the established direction contained in AFSC/CC Policy Letter 22. Although this Policy Letter has been in effect for over one year, the Quality Horizons study team sought specific commercial practices that could further facilitate compliance with the existing policy.

An important step toward better hardware must be a better contract. Complexity and sophistication are not the ingredients that result in a quality contract. The most important ingredient is a clear set of performance specifications. The intended use of the desired equipment must be described in such a way that performance in the operational environment can be readily measured.

The statement of work should spell out clearly that performance will be measured during field use. The contractor has to know what it will take to obtain user satisfaction. The Statement of Work should then be subject to pre-Request for Proposal planning to include participation by potential proposers to assure a clear understanding of the requirement, the risks, and the responsibilities. Maximum use should be made of draft Request For Proposals and more serious consideration given to alternate proposals. Contractors should be encouraged to submit alternate proposals that define cost deltas and risks for requirements they consider to be cost drivers. Also, alternate approaches to field support, such as interim contractor support, until support equipment can be in place and operating, or full contractor support for an indefinite period should be proposed. Planning must include a careful analysis of the timing of the changeover to full organic support.

During the team's travels, it was found that incentives are not a satisfactory substitute for a well defined requirement. Complicated contractual incentives often create difficult problems and generate adversary relationships. Better results could be obtained by concentrating on the requirements. Unfortunately contracting officers spend most of their time working

with their financial and legal advisors and little with their technical support personnel. Reliability Improvement Warranties, or any other warranty provision should be applied only on a selective basis, generally in competitive acquisitions, and require a full understanding of all parties, (user, AFLC, ATC, etc.,) as to the responsibilities of the Government under the terms of the contract. The objective of the Reliability Improvement Warranty can also be achieved by doing a better job of describing the requirements, emphasizing product assurance in the beginning, and requiring the contractor to provide field support.

The AFSC/CC initiative on the use of past performance in source selections will make a significant contribution to the effort to improve product assurance. This effort should continue, and be strengthened, if possible, recognizing that it is not as easy for the Government to make the judgments that a commercial firm can make because of the emphasis placed on low bidders and the fact that, in a protest, the burden of proof would be on the Government. The rating system described under Part V.G. will emphasize the AFSC intent to use past performance to impact future awards.

To further support General Slay's efforts toward program baselining, another initiative that should be implemented, on a selective basis, is deletion of the unilateral right of the Government under the "Changes" article. This would not stop changes, but would require that they be defined and priced before they are authorized. This disciplined approach will help insure that all aspects of the change are evaluated before it is incorporated. This will also emphasize AFSC intention to hold to specification baseline and discourage contractor use of his sustaining engineering force to market changes.

An appropriate program should be selected to test a leasing arrangement similar to the Navy's LEASESAT program. At the very least, AFSC should compare the cost of a leasing arrangement to the cost of the normal acquisition procedure. This could be used on a commercial derivative, such as a mission support or trainer aircraft, ground communication gear, or on a simulator.

It is important to consider, when planning new programs with potential high production volume and low to moderate initial investment, whether substantial savings could be made by keeping two or more firms in the

production phase to maintain competition throughout the program. Authorization to do so presently exists only under Title 10 USC 2304(a)(16), which authorizes negotiation of purchases in the interest of industrial mobilization. Authorization to purchase production items from two sources would maintain competition and could result in increased quality as well as reduced prices.

Clearly there are advantages to be gained by using commercial techniques when appropriate, but there are some cautions that must be observed. First, to gain the advantages of commercial buying some aspects of the commercial environment will have to be provided to the manufacturer. For example, configuration control may have to be left to the supplier so that he has the flexibility to correct deficiencies in a timely manner. Government involvement in Material Review Boards may have to be waived, and responsibility for government furnished components will have to be clearly established between the parties. Most importantly, commercial techniques are not appropriate when pushing the state-of-the-art, or when schedule is legitimately a priority concern.

Secondly, it must be recognized that there are some aspects of the Government environment that conflict with commercial practices, over which AFSC has little or no control. A few of these environmental factors are the annual appropriations process, the requirement for synopsis, the Truth in Negotiations Act, and the requirement to buy from the lowest responsive and responsible bidder. Business strategies must take into account the social and economic programs which are mandatory for Government buying, but which may conflict with sound commercial practices.

Thirdly, commercial warranties will not go very far toward preventing or resolving our product assurance problems. Generally they cover only materials and workmanship, for a specified time, and would have been of little value in the solution of the quality problems experienced in the last few years with AFSC programs. A notable exception is found in the case of commercial transport aircraft. Warranties for these aircraft do include a provision that permits design changes to correct problems. In other cases, commercial firms will correct design problems because of product liability, customer or consumer pressure, to assure future business, but not just because of their legal obligations under the written warranty.

In summary, the contract document must be put in its proper perspective. It will not make an airplane fly or an engine run. Management attention to product assurance and properly defined specifications are the most important influences toward improved quality and reliability. Warranty clauses or other special contract provisions are only tools to assist in obtaining improved products. Still, the Command can, and should, improve its contracting techniques to emphasize commercial procedures, where they can be sensibly used. A handbook, published by AFSC, containing commercial techniques, including warranties, will facilitate compliance with AFSC policies and assist in the goal of better quality products at reasonable prices.

G. Motivation

Although the Quality Horizons' team looked at motivation techniques at various places visited and found few that have endured; the team did discover that many of the tools already available to AFSC are not being used to full advantage. In many cases, Systems Command policy already clearly indorses the motivation techniques discussed in this section. Detailed criteria and instructions, or better information, are needed to more effectively implement Command policy.

AFSC should place more emphasis on the withholding of progress payments when a contractor is not living up to his contract promises, and withhold acceptance of items that do not conform to contract requirements. Specific criteria should be established and promulgated through policy letters or regulations, as determined appropriate by AFSC/PM. There must be a clear demonstration to industry that AFSC will no longer permit quality to be subordinated to schedule. In competitive programs, consideration should be given to omission of the progress payments provision to encourage timely delivery of a quality product.

Programs should be selected to implement a limited time, failure free warranty provision which would allow for final acceptance of a product after 60 or 90 days of field use. The contractor would be responsible for correcting all failures during the warranty period prior to acceptance and payment. Such an approach would also have the built-in advantage of providing timely and accurate failure data for the contractor's analysis which would facilitate corrective action based on knowledge of the inherent failure modes.

The cost of money to support this planned delay in payment would have to be recognized, but the use of the technique would increase the level of attention to product assurance and thus be a very worthwhile investment.

There is almost universal agreement in the U.S. defense industry that the award fee technique is effective as a motivator. Attention to product assurance disciplines in award fee plans will result in more effective and concentrated front end efforts. Award fee contracts are being used extensively, and this use should continue. Product assurance emphasis in award fee plans should be enhanced by the organizational changes recommended. The AFSC "Guide to Award Fee" should be modified to provide guidance in the use of award fees to achieve product assurance objectives.

Contractor rating or "experience" lists have been difficult to sustain in AFSC's acquisition environment, and past performance reports could not be used as an exclusive criteria in source selection. Such a system would, however, make the buying activity aware of potential problems and risks of doing business with a particular source. This information could be used in business strategy, source selection, and other related planning forums.

The rating system should also incorporate positive incentive aspects, for example, a program of recognition through publicity, and eventually through selective withdrawal of Government surveillance, for firms demonstrating a high level of attention to quality and sustaining a record of delivery of supplies conforming to all contract requirements.

Regarding motivation programs for individual workers, the Human Resources Laboratory (HRL) in coordination with union leaders, should evaluate the need for a general program that could be tailored by contractors to their individual requirements. If the need is validated, a program should be created and implemented, to encourage contractors to recognize and reward individual worker quality performance.

H. Government Involvement/Surveillance

The various governmental approaches to contractor surveillance emphasize a disciplined, systematic program to assure that the contractor performs to contract

requirements and delivers an acceptable product. The FAA's approach emphasizes maximum attention on defining the requirements and ensuring that the contractor fully understands them. After the contractor develops an acceptable plan and verifies his capability to perform to it, the FAA reduces their presence in the contractor's plant to the minimum number of representatives required to monitor the contractor's compliance through statistical sampling techniques.

The Army (DARCOM) and the Navy (NAVMAT) also put their emphasis on developing thoroughly defined requirements early in the acquisition life cycle. Their product assurance approach ensures that design requirements are developed and the proper controls established by the contract administration offices. To perform these controls, the NAVPROs are currently implementing a reduced verification technique through their Quality Assessment Program to monitor contractors with fewer people. While the Army performs some of their own contract administration, they rely primarily on DCAS for this function. Both the Army and DLA use the quality assurance evaluation procedures contained in DLAM 8200.1 (similar to AFCMDR 74-1).

DCAS is presently testing their Contractor Assessment Program approach to assure contractor compliance to established Government program requirements. This approach requires the contractor to accept more responsibility for product quality by performing more of the assurance tasks that previously were accomplished by the Government Quality Assurance Representative (QAR). Although there is limited CAP data available, contractor and DCAS representatives in the test program maintain that CAP is effective in attaining product quality with minimum Government involvement.

AFCMD's contractor surveillance approach is implemented through the Contractor Management System Evaluation Program (CMSEP). AFPROs use CMSEP to verify contractor compliance to the aggregate of contract requirements at each plant established by various program offices through a management systems approach. AFPRO functional divisions are aligned parallel with the contractor's, and each division monitors that functional area for all contracts. This approach relies on condition questions (management system indicators) to verify the existence and adequacy of the contractor's written instructions, worker compliance with those instructions and product inspection. The QA function uses this approach for

verification of both management and work instruction procedures. However, the verification effort of CMSEP is only as good as the specific product requirements established by each program office. More structured and disciplined procedures must be developed and implemented to establish contract technical requirements and assure the coordination of those requirements with the contract administration office. These procedures must assure the complete understanding of the technical requirements that need special attention due to criticality or risk by product assurance personnel at all levels. Data accumulation and reporting procedures must be improved to enhance communication between each product assurance organization. Individual "lessons learned" must be collected and disseminated to all organizations to prevent problems encountered and solved at one organization from occurring at another. New methods and procedures found effective at one organization should be made available to others for consideration. Each product assurance organization must accumulate the technical expertise necessary to support the program manager and engineering staff in assuring that the desired reliability, corrosion prevention, system safety, producibility, inspectability, standardization, and maintainability requirements are attained. Product assurance personnel must assure that trade-off studies are conducted. Assessments should be made in selected instances to verify contractor product assurance involvement in the internal design process. Emphasis should be directed toward the contractor's performance of product assurance tasks with Government review of the verification data.

The recommended approach to product assurance surveillance of the contractor's contract compliance is the Minimum In-Plant Surveillance (MIPS) Program. The purpose of MIPS is to shift the nature of plant-level activity away from conformance verification, toward prevention, and to reduce the overall depth of surveillance in line with contractor product assurance performance. Any decrease in surveillance must be based on objective data and on-site analysis to determine the degree of excellence sustained by the contractor. Guidelines for reducing conformance verification effort should be included in implementing directives. Procedures must also be developed for program office concurrence in MIPS evaluations. In addition, the contractor should be encouraged to make formal application for reduced Government surveillance. Special care must be taken to provide for a fair and equitable consideration of the contractor's application.

The nucleus of the MIPS program should include:

1. Criteria that must be achieved for contractors to make application for reduction of Government surveillance.

2. The data and format the contractor's application should include.

3. The delegation of the approval of the contractor's application to the AFPRO and the program office product assurance representatives.

4. An appeal procedure that permits the contractor to request further review of a disapproved application by the AFCMD Commander and the Program Manager.

The MIPS program incorporates the optimum mix of the various reduced surveillance programs observed by the Quality Horizons' Study Team such as the FAA's Quality Assurance System Analysis Review (QASAR) and Designated Manufacturer Inspection Representative (DMIR) programs and DLA's Contractor Assessment Program (CAP). The MIPS program also recognizes that detection of nonconformances and in-plant problems does not appear to be manning sensitive. In other words, nominal increases or decreases in CAO quality assurance personnel in-plant does not appear to result in a significant change in the number of nonconformances found by Government inspectors. There is an obvious decrease in nonconformance detections when manning is reduced below an undefined threshold level where the number of inspections actually performed is very low or zero. The MIPS program would also capitalize on the contractor's intrinsic motivation to achieve greater internal control of manufacturing and inspection operations through the relaxation of government verification activities.

The product assurance representatives of the program office, the prime contractor and the AFPRO must assure that methods and procedures are developed for attaining adequate government surveillance at subcontractor's plants. The Government representatives at the subcontractor's plant must understand the extent and method of their involvement in support of the acquisition. Government source inspection requirements must be mutually developed and included in formal Memorandums of Agreement (MOAs) or Letters of Instruction (LOIs).

There also must be a special effort to take advantage of new and improved quality technologies through the AF Laboratories. Procedures need to be developed that will promote the distribution of the new and improved techniques to all AFSC product assurance organizations. The AFSC quality technology (Q-TECH) program must complement the AFSC Man-Tech program. Some of the new or improved techniques may require the development of training courses to improve the capabilities of the personnel assigned to the product assurance organizations. If training is required, it should be developed and scheduled on a priority basis.

I. Life Cycle Product Assurance

The interviews, studies, and analyses accomplished by the Quality Horizons Team convinced the members that certain actions are necessary to improve product quality and that quality will improve if these actions are taken.

Top management attention to quality, and the willingness to sacrifice schedule to achieve it, is a must. A disciplined approach to planning, utilizing the assurance disciplines, is common to all successful programs. Also common to many organizations, both commercial and government, is the trend toward organizational change to recognize the interrelated aspects of the assurance disciplines and give them the potency of an integrated, top level organization. The combined effect of the foregoing is a front end emphasis on quality that may not eliminate, but will minimize, surprises in the field environment.

Contracting techniques need to be improved. There are commercial techniques that should be used in more AFSC procurements. Improvements in business strategy planning, in the direction of product assurance, should be made. A better job of motivating the producer can and should be done, both through contractual provisions and other programs.

As the recommended programs begin to take hold, and reduced government surveillance becomes possible, additional manpower can be applied to the front end efforts to increase quality, and the program will gain momentum toward the proper balance of product assurance throughout the life cycle. Only through continuous involvement throughout the life cycle can AFSC assure the delivery of top quality products to the using commands.

Figure 10 lists the major systems acquisition tasks to be performed by the new product assurance organization and illustrates when these tasks should be performed in the life cycle. This Figure is not intended to be all inclusive nor totally precise. Further refinements will have to be made after the new organization is established. However, the intent is to show that HQ AFSC must orchestrate a systematic life cycle approach to make the concept viable.

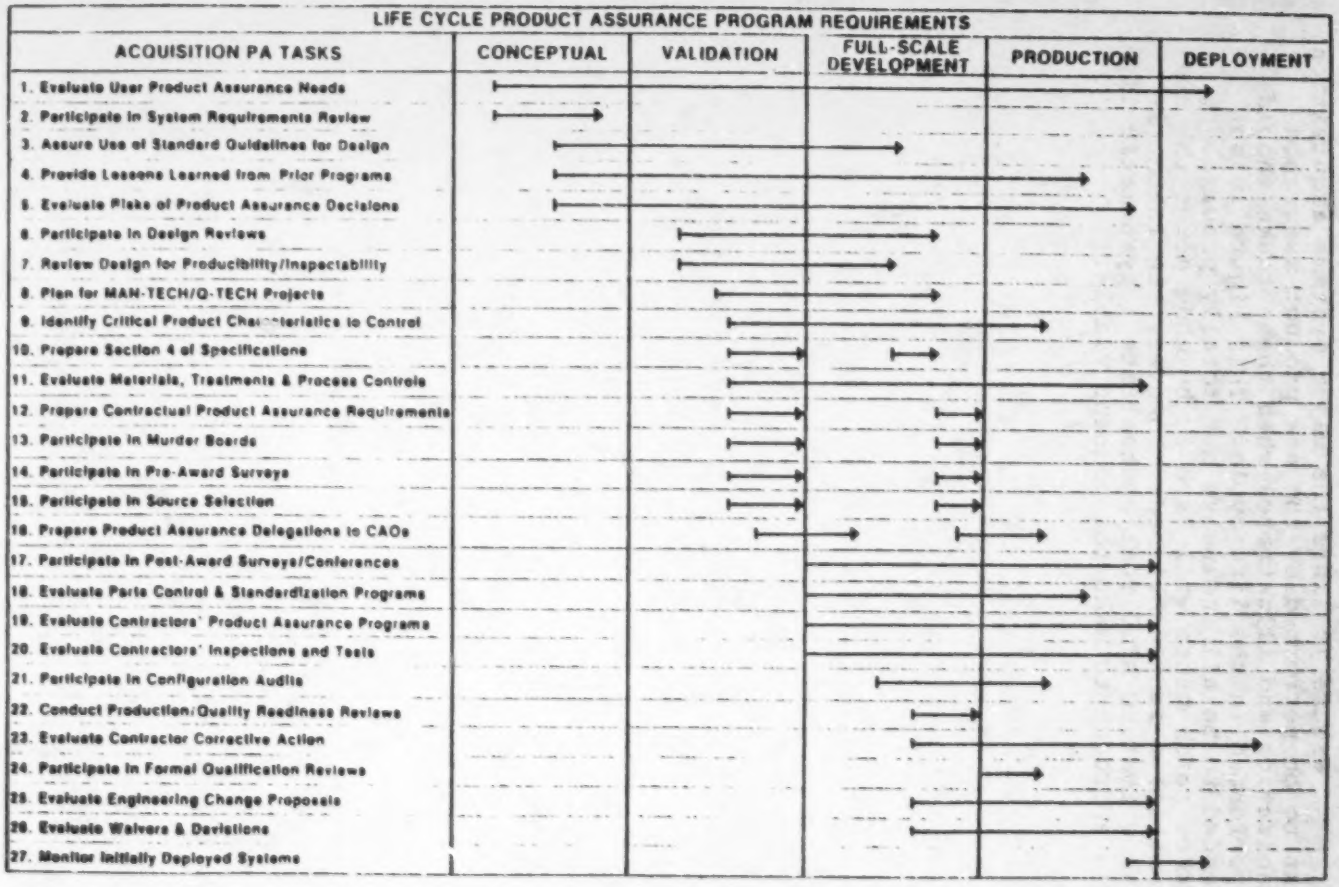
LIFE CYCLE PRODUCT ASSURANCE PROGRAM REQUIREMENTS
ACQUISITION PA TASKS
CONCEPTUAL
VALIDATION
FULL-SCALE DEVELOPMENT
PRODUCTION
DEPLOYMENT
1. Evaluate User Product Assurance Needs
2. Participate in System Requirements Review
3. Assure Use of Standard Guidelines for Design
4. Provide Lessons Learned from Prior Programs
5. Evaluate Risks of Product Assurance Decisions
6. Participate in Design Reviews
7. Review Design for Producibility/Inspectability
8. Plan for MAN-TECH/Q-TECH Projects
9. Identify Critical Product Characteristics to Control
10. Prepare Section 4 of Specifications
11. Evaluate Materials, Treatments & Process Controls
12. Prepare Contractual Product Assurance Requirements
13. Participate in Murder Boards
14. Participate in Pre-Award Surveys
15. Participate in Source Selection
16. Prepare Product Assurance Delegations to CAOs
17. Participate in Post-Award Surveys/Conferences
18. Evaluate Parts Control & Standardization Programs
19. Evaluate Contractors' Product Assurance Programs
20. Evaluate Contractors' Inspections and Tests
21. Participate in Configuration Audits
22. Conduct Production/Quality Readiness Reviews
23. Evaluate Contractor Corrective Action
24. Participate in Formal Qualification Reviews
25. Evaluate Engineering Change Proposals
26. Evaluate Waivers & Deviations
27. Monitor Initially Deployed Systems

FIGURE 10

VI. IMPLEMENTATION

Many of the industry executives interviewed by the Quality Horizons Study Team expressed an attitude that things will not change in the government contracting arena. While they were supportive of the study objectives, they did express concern that the findings would not be accepted nor the recommendations implemented. They felt that the team would not be able to generate enough emphasis to overcome the inertia of the bureaucracy. Therefore, it is most important that AFSC/CC implement selected changes and give those changes the widest possible publicity, perhaps through a video tape discussion. This would be a positive motivator, not only for product assurance, but for other AFSC initiatives. In addition, a letter should be sent to the field commanders to implement the product assurance program, and emphasize that schedule may be traded-off for quality, reliability and/or user needs.

The Quality Horizons Report identifies new and revitalized approaches to enhance the product assurance of hardware in the hands of the user. Essential to the successful outcome of many of these recommendations will be the continuous implementation, tracking and follow-up of the action line items presented in Appendix I (Action Plan) of this report. Following the consideration of these recommendations by the AFSC Council, and selection of those to be implemented by the Commander, it is recommended that a General Officer Steering Group (GOSG) be formed including both field and Headquarters members, to meet and track progress on a quarterly basis for the first year and semi-annually thereafter. The Commander, AFSC should be given progress reports within 15 days after each GOSG meeting.

It is recommended that this joint GOSG be made up of persons occupying the following positions:

a. AFSC/CV (Chairman)

b. DCS/Systems, Hq. AFSC

c. DCS/Contracting and Manufacturing, Hq. AFSC

d. Commander, AFCMD

e. A Program Manager from a major weapons system program to be selected by AFSC/CC.

The Chief of the Quality Assurance Office, Hq AFSC (PMN) will function as the permanent secretariat and recorder for this GOSG, and a member of the Quality Horizons Study Team should serve as an advisor.

To continue the line of communication with representatives of key industrial associations, it is recommended that a representative from the National Security Industries Association and one from the Aerospace Industries Association be designated as advisors to this group and participate in appropriate sessions. It is further recommended that one of these representatives have a strong background in Product Assurance and the other in the Contracts area.

APPENDIX 1

ACTION PLAN

QUALITY PLANNING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION*
1.1	Product Assurance Regulation	Develop a composite AFSC Regulation that defines the integrated tasks and interrelationships among the functional disciplines required to implement the product assurance concept and stress preventive efforts early in design rather than through emphasis or conformance inspection during production.	V.B.	AFSC/SD	AFSC/PM	6 months
1.2	Corporate Memory Handbooks	Develop AFSC handbooks that provide specific guidance for tailoring and applying the available tools and techniques in each of the functional disciplines listed below. This guidance will include the benefits provided by these tools and techniques as well as the risk of omitting them and cost trade-off guidance. The OPRs will act as command focal points in assuring that lessons learned are incorporated in revisions.	V.B.			
		Quality Assurance		AFCMD/QA	ESD/TO	9 months
		Reliability		ESD/RADC	SAMSO/MN	9 months
		Maintainability		ASD/EN	ADTC/SD	9 months
		System Design Safety		ASD/SE	ADTC/SE	9 months
		Corrosion Prevention		AFML	ASD/EN	9 months
		Manufacturing		ASD/PM	ESD/TO	9 months
		Standardization		SAMSO/LG	ASD/AW	9 months

*After action item approval by AFSC/CC

ACTION PLAN (Continued)

GOVERNMENT INVOLVEMENT/SURVEILLANCE

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
2.1	Introduction to Product Assurance	Develop a briefing to present the concept of Product Assurance to AFSC Product Divisions, AFCMD, HQ DLA and NAVMAT. Briefing to include definition of Product Assurance, Quality Horizons Observations, and approved recommendations; e.g. MIPS. Emphasize prevention tasks by Program Office and specific support required of CAO, and the interrelationships between these organizations.	V.B.	AFSC/PM	AFSC/SD	5 months
2.2	Introduction to Product Assurance	Present the briefing.	V.B.	AFSC/PM	AFSC/SD	12 months
2.3	Minimum In-Plant Surveillance Program	Develop an AFSC regulation to establish the MIPS Program. The program will provide criteria and procedures for contractors to apply for reduced in-plant surveillance by supplying objective data of sustained quality performance. AFPRs/SPOs will have approval authority. Contractors may escalate adverse decisions to AFCMD/CC and program managers.	V.H	AFSC/PM	AFCMD/QA	6 months
2.4	Minimum In-Plant Surveillance Program	Implement program by AFSC/CC letter to contractor top management to motivate contractor to apply for MIPS.	V.H.	AFSC/PM	AFCMD/QA	7 months

ACTION PLAN (Continued)

ORGANIZATION

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
3.1	Product Assurance Organization	Combine product assurance disciplines (e.g. reliability, maintainability, quality, corrosion control, standardization, system safety, manufacturing) into one separate staff organization at HQ AFSC, AFCMD, AFPROs, Product Divisions and Program Offices. The new organization is to report to the Commander. Revise organization and functions documents and applicable position descriptions.	V.C	AFSC/HO	AFSC/PM	6 months
3.2	Alternate Product Assurance Organization	If the above action is not supported implement two phased reorganization. Phase I - Combine product assurance disciplines at HQ AFSC to gain field attention and emphasize the need for enhanced product quality through design efforts. Withhold further implementation pending evaluation as to whether reorganization at field activities is necessary to achieve the proper attention to product assurance and to institutionalize concept. Phase II - Combine disciplines at Product Divisions/AFCMD as determined by evaluation results of Phase I.	V.C.	AFSC/HO	AFSC/PM	Phase I 6 months Phase II 18 months

ACTION PLAN (Continued)

MANNING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
8.1	Initial Manning for Product Assurance	Identify AFSC manpower performing product assurance functions. Transfer manpower to new organization at HQ AFSC, AFCMD, AFPROs, Product Divisions and Program Offices if Action Item 3.1 is approved. If Action Item 3.2 is approved transfer manpower at HQ AFSC only. Transfer manpower at other organizations based upon evaluation and decision reached as a result of Action Item 3.2.	V.D.	AFSC/MO	AFSC/DP	6 months if Action Item 3.1 is approved. 6 months for HQ AFSC if Action Item 3.2 is approved and 18 months for other organizations.
8.2	Policy Statement on Contracting-Out	Issue Policy Statement to encourage contracting-out for those product assurance skills not available in AFSC.	V.D.	AFSC/PM	AFSC/JA/MO	8 months
8.3	Re-allocation Study	Study Product Assurance manning levels and tasks to determine optimum levels of manning at HQ AFSC, Product Divisions, and AFCMD.	V.D.	AFSC PMAG	AFSC/MO	9 months
8.4	Personnel Transfer Plan	Develop and implement plan to transfer personnel to achieve optimum manning levels in accordance with Action Item 8.3.	V.D.	AFSC/DP	AFSC/PM	8 months to develop plan. 18 months to complete implementation.

ACTION PLAN (Continued)

EDUCATION/TRAINING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
5.1	Intern Program	Develop, provide manpower for and implement a formal intern program to provide continual source of qualified personnel. Program to provide 3 years of formal and on-the-job training and output a minimum of 25 graduates per year.	V.E.	AFSC/DP	AFSC/SD/PM	10 months
5.2	Educational Levels	Determine the educational level of the contractor's product assurance organization where there is an AFPRO. Establish a goal of educational comparability between AFPRO and contractor. Develop plan to achieve this goal.	V.E.	AFCMD/QA	AFSC/PM	9 months
5.3	Workforce Training	Determine skills necessary to accomplish product assurance functions. Inventory skills existing in workforce. Develop and implement formal training program to upgrade and maintain required skills.	V.E.	AFSC/DP	AFSC/PM	6 months
5.4	Contracting-Out Training	Evaluate training programs and capabilities available within DoD and contract-out for those which are unavailable.	V.E.	AFSC/DP	AFSC/PM	9 months

EDUCATION/TRAINING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
5.5	Top Management Training	Assure that Product Assurance Training is included in Professional Military Education programs and other executive courses. Training objectives to emphasize Product Assurance benefits and risks due to omission of Product Assurance tasks.	V.E.	AFSC/DP	AFSC/PM	9 months
5.6	Education With Industry (EWI)	Study the benefits of establishing an EWI pprogram for both civilian and military personnel in product assurance and consider expanding the total EWI program to include civilians. Establish program if warranted.	V.E.	AFSC/DP	AFIT/CI	18 months
5.7	Civilian Career Program	Develop an AFSC regulation to establish a product assurance career program to provide for career counseling, appraisal and progression (similar to the Procurement and Manufacturing Civilian Career Development Program, AFSCR 50-5).	V.E.	AFSC/PM	AFSC/DP	12 months

CONTRACTING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
6.1	"Changes" Clause	To further support and emphasize AFSC/CC policy regarding baselining, prepare a modified "Changes" Article, omitting the unilateral right to make changes. Obtain ASPR deviation to permit trial use. Include modified clause in selected contract(s) to emphasize government intention to hold to specification baseline and discourage contractor use of sustaining engineering force to market changes.	V.P.	AFSC/PM	AFSC/JA	7 months
6.2	Field Acceptance	Develop provisions for equipment acceptance at the operating location after field use - i.e. 30, 60, or 90 days. A short term failure free warranty to assure operational suitability. Select candidate programs and implement.	V.G.	AFSC/PM	AFSC/JA	12 months
6.3	Progress Payments Omission	Select competitive programs at each Product Division for omission of Progress Payments clause. Omit clause in selected programs to encourage timely delivery of quality products.	V.G.	AFSC/PM	AFSC/JA	8 months
6.4	Progress Payment Withholding	Establish criteria for withholding of Progress Payments with emphasis on Product Assurance problems, and publish as AFSC policy.	V.G.	AFSC/PM	AFSC/JA	4 months

CONTRACTING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
6.5	Dual Sourcing	Establish criteria for programs with potential savings if production dual sourced; such as high volume items requiring low to moderate capital investment. Select candidate programs and request SAFGC/SAFAL interpretation for negotiation authority (other than 10 USC 2304(a)(16) (Industrial Mobilization) to continue at least two sources into production. Implement program.	V.F.	AFSC/PM	AFSC/JA	10 months
6.6	Motivation Program	Evaluate the need for and develop in co-ordination with union leaders and Human Resources Lab, an umbrella motivation program that could be tailored by contractors to their individual requirements. Contractors would be encouraged to recognize and reward worker quality performance.	V.G.	HRL	AFSC/PM AFCMD	15 months
6.7	Award Fee	Develop Award Fee policy to recognize Product Assurance as an element of Award Fee plans. Modify AFSC "Guide to Award Fee", PMPS, Dec 77, to include specific examples for the use of Award Fees to motivate enhanced product quality throughout the acquisition cycle.	V.G.	SAMSO/PM	ASD/PM	3 months

ACTION PLAN (Continued)

CONTRACTING

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
6.8	Leasing	Select candidate programs where commercial leasing techniques or lease-purchase arrangements would be appropriate (i.e. simulators, trainer aircraft, etc.). Implement the program; collect and publish lessons learned.	V.F.	AFSC/PM	AFSC/JA	12 months
6.9	Commercial Warranties/ Practices	Prepare handbook containing commercial contracting techniques, negotiation strategy and tactics, and criteria for application of the clauses, warranties and techniques. Purpose of the handbook is to facilitate proper use of commercial techniques and to promote, with specifics, current AFSC policy.	V.F.	ASD/PM	AFSC/PM	6 months
6.10	Business Strategy	Revise AFSCR 70-2 to define Product Assurance considerations so that AFSC can capitalize on commercial approaches to enhance product quality early in the acquisition phase.	V.F.	AFSC/PM	AFSC/SD	6 months

ACTION PLAN (Continued)

TOP MANAGEMENT ATTENTION

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
7.1	Management Emphasis	Include emphasis on product assurance objectives to industry/AFSC top management in next AFSC/CC video tape.	VI.	AFSC/PM	AFSC/OI	9 months
7.2	Management Emphasis	Prepare and distribute AFSC/CC letter to all AFSC field commanders to implement product assurance program and emphasize willingness to trade-off schedule for quality, reliability and customer satisfaction.	VI.	AFSC/PM	AFSC/CS	2 months
7.3	Management Appreciation of Product Assurance Approach	Develop training program and present to top management in all organizations. Training objectives to emphasize product assurance benefits and risks due to omission of product assurance tasks.	V.E.	AFSC/DP	AFSC/PM	12 months
7.4	Program Reviews	Revise AFSCR 800-23 to have Program Managers/AFPRs present product assurance status (accomplishments and problem areas) during PAR/CAR briefings.	V.B.	AFSC/SD	AFSC/PM	6 months
7.5	Program Reviews	Develop and distribute policy guidance using applicable data items and military standards to require contractor presentation of product assurance status during program technical and management reviews.	V.B.	AFSC/SD	AFSC/PM	6 months

ACTION PLAN (Continued)

MISCELLANEOUS

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
8.1	General Officer Steering Group (GOSG)	Establish a General Officer Steering Group consisting of representatives from HQ AFSC, Product Divisions and AFCMD to provide a balanced view toward Product Assurance. The GOSG will provide direction and track the Quality Horizons Study recommendations selected for implementation by the AFSC/CC.	VI.	AFSC/CS	AFSC/PM	2 months
8.2	Data Systems Guidance	Develop AFSC pamphlet to enhance the use of the product assurance data available in existing Air Force data collection systems e.g. AFM 66-1 data by the program offices and contractors. The pamphlet should identify the type of data, strengths and weaknesses, and the method of obtaining the data in each system.	V.H.	AFSC/SD	SAMSO/MN	10 months
8.3	Quality Technology (Q-TECH)	Establish guidelines for prioritizing Q-TECH projects and funding to assure that Q-TECH remains parallel and abreast of the Manufacturing Technology Program. Disseminate results of Q-TECH projects throughout AFSC.	V.H.	AFSC/PM	AFSC/DL	18 months

MISCELLANEOUS

ITEM	SUBJECT	ACTION REQUIRED	REPORT REFERENCE	OPR	OCR	SCHEDULED COMPLETION
8.4	Quality Technology (Q-TECH)	Develop training programs to assure that product assurance personnel remain current with emerging quality technologies.	V.E.	AFSC/DP	AFSC/PM	18 months
8.5	DLA Liaison Offices	In consonance with DLA, establish DLA liaison offices at each Product Division to facilitate communications, problem resolution, and emphasize Product Assurance in design and development phases.	V.C.	AFSC/PM	ESD/TO	12 months

STUDY OBJECTIVES

- EVALUATE AFSC APPROACH TO QA
- IDENTIFY CHANGES WITH POTENTIAL TO:
  - IMPROVE END ITEM QUALITY
  - MAKE CONTRACTORS MORE RESPONSIBLE FOR THEIR PRODUCTS
  - MAKE MORE EFFECTIVE USE OF RESOURCES
  - APPLY APPROPRIATE COMMERCIAL PRACTICES

CURRENT CONCERNS

- CURRENT TECHNIQUES
  - LITTLE CHANGE IN 20 YEARS
  - AF IN–PLANT PRESENCE HIGH
  - LACK OF STRONG POSITIVE/NEGATIVE INCENTIVES
  - LITTLE APPLICATION OF PROVEN COMMERCIAL PRACTICES
- AFSC QA WORK FORCE
  - NUMEROUS RETIREMENTS PENDING
  - LIMITED EDUCATION
  - NOT KEEPING PACE WITH NEW TECHNOLOGY
- AFSC QA SYSTEM
  - PERHAPS EMPHASIS IN WRONG PLACES–AF INSPECTION NOT ALWAYS THE ANSWER
  - AFSC MANAGEMENT ATTENTION TO QA VARIES
  - LIMITED APPLICATION OF LESSONS LEARNED

KEY STUDY AREAS

- EXAMINE WAYS TO EFFECTIVELY INCENTIVISE CONTRACTORS FOR A BETTER PRODUCT
  - BETTER APPLICATION OF CURRENT TOOLS
  - COMMERCIAL PRIME/VENDOR RELATIONSHIPS
  - RFP, SPECIFICATIONS, PAST PERFORMANCE
  - AWARD FEE, WITHHOLD PAYMENTS
- EXAMINE WAYS TO RESTRUCTURE AF IN-PLANT QA PRESENCE
  - CERTIFICATION PROGRAM
  - COMMERCIAL PRACTICES—FOREIGN & DOMESTIC
  - DLA, FAA, NASA, FOREIGN GOVT EXPERIENCE
- EVALUATE CURRENT QA WORK FORCE AND IDENTIFY NECESSARY CHANGES
  - EDUCATION/TRAINING
  - RECRUITMENT
  - NUMBERS AND SKILLS REQUIRED

- IDENTIFY REQUIRED POLICY AND ORGANIZATION CHANGES
  - CONTRACT POLICY/MANAGEMENT
  - ROLES OF HQ AFSC, HQ AFCMD, PRODUCT DIVISIONS, IN-PLANT OFFICES AND SPOs
  - PERSONNEL REQUIREMENTS/EDUCATION
  - PRODUCT ASSURANCE (QA + ILITIES) OFFICE
  - AFSC MANAGEMENT ATTENTION TO QA

STUDY ACTIVITIES

- REVIEW PREVIOUS STUDIES AND RECOMMENDATIONS
- VISIT OTHER GOVERNMENT AGENCIES SUCH AS NASA, FAA, DLA, NAVY, ARMY, DOD AND DEFENSE DEPARTMENTS OF GERMANY, NORWAY AND JAPAN FOR IDEAS
- VISIT COMMERCIAL FIRMS IN U.S., EUROPE AND JAPAN IN AUTO, ELECTRONIC, AIRCRAFT, AND OTHER INDUSTRIES TO EXAMINE COMMERCIAL AND CONTRACTUAL PRACTICE/TECHNIQUES
- VISIT DEFENSE AND COMMERCIAL SUBCONTRACTORS TO UNDERSTAND QA INSTRUCTION AND CONTRACTUAL RELATIONSHIPS WITH PRIMES
- VISIT AFIT AND AMETA TO DEVELOP QA EDUCATION PROGRAMS
- UTILIZE INDUSTRIAL ASSOCIATIONS AS A SOUNDING BOARD FOR CONCLUSIONS AND RECOMMENDATIONS
- OBTAIN PRODUCT DIVISION AND AFCMD COMMANDERS' INPUTS ON RECOMMENDATIONS PRIOR TO PRESENTATION TO COMMANDER, AFSC

STUDY TEAM

STUDY DIRECTOR:	COL BERNARD L. WEISS, ASD/PM
DEPUTY STUDY DIRECTOR:	ARTHUR A. SHANNON, AFCMD/QA
INCENTIVES/CONTRACT CLAUSES:	LT COL MICHAEL M. MCMILLAN, AFSC/PM DONALD ROBINSON, ASD/PMH
ACQUISITION REQUIREMENTS:	LT COL RICHARD TRACEY, SAMSO/MN
POLICY/REGULATIONS/PERSONNEL:	IRA EPSTEIN, AFSC/PMN
SECRETARIAT:	CAPT RAYMOND R. HONAKER, ASD/PMD CAPT JOHN McNALLY, ASD/PMD

ADVISORS

CONTRACT LAW:	CAPT C. B. GRESHAM, AFLC/JAN
INDUSTRIAL FEEDBACK:	NSIA/AIA COMMITTEES ON QUALITY AND CONTRACTS
QA OPERATING OFFICIALS ADVICE:	PRODUCT DIVISION QA DIRECTORS

Senator QUAYLE. We stand adjourned.
[Whereupon, at 12:34 p.m., the task force adjourned.]

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